Main Roads Western Australia

Goldfields Highway Wiluna to Meekatharra PortLink Project
Environment Impact Assessment and Management Plan

September 2014

Executive Summary

This report is subject to, and must be read in conjunction with, the limitations set out in Section 1.8 and the assumptions and qualifications contained throughout the Report.

Introduction

Goldfields Highway extends almost 800 kilometres (km) from south of Kambalda in the Goldfields, to Meekatharra, in Western Australia's Mid-West. The section of Goldfields Highway between Wiluna and Meekatharra is approximately 182 kilometres (km) in length and is a key route that links industry and community between the Goldfields-Esperance region and the Mid-West / Pilbara regions. However, the majority of this section of the highway is unsealed. Sealing of this highway (the Project) has been proposed as part of the PortLink Inland Freight Corridor Development Plan.

Main Roads WA commissioned GHD Pty Ltd (GHD) to prepare an Environmental Impact Assessment (EIA) and Environmental Management Plan (EMP) for the Project. This EIA and EMP will be used to identify, assess and manage the anticipated environmental impacts associated with the Project.

The Project involves the investigation, design and construction of the Goldfields Highway Wiluna to Meekatharra Section. Main Roads proposes to upgrade this section to highway standard.

The Project included the following components:

- 145 km of resealing works
- ~ 18 km of minor re-alignment, raising and sealing of the road
- Six intersection upgrades
- Drainage improvements including floodways and levees
- ~220 km of fencing
- Eight material pit extraction sites
- Two construction camp areas

The EIA included desktop assessments of relevant environmental aspects and a Level 1 flora and fauna field survey. Aboriginal heritage was excluded from this assessment as it is being conducted as a separate assessment.

Project location

The Project is located in the Main Roads WA Goldfields-Esperance and Mid-West region of Western Australia, within the Shires of Wiluna and Meekatharra.

The desktop assessment considered a wider area than that of the field assessment. The Survey Area for the flora and fauna field survey extends 180 km from Wiluna (SLK 613.28) to Meekatharra (SLK 793.28) and includes a one kilometre buffer (i.e. 500 metres (m) either side) centred on the Goldfields Highway. The Survey Area covers 17,962 hectares (ha).

The proposed Impact Area is the area that will be potentially impacted by the Project. The impact assessment was conducted on the Impact Area. The proposed Impact Area is 534 ha and includes:

- Areas of road upgrade and realignment minus the existing road, where it overlaps
- Drainage levees
- Eight material pits and access tracks at:
  - SLK 614 (1)
  - SLK 614 (2)
  - SLK 614 (3)
  - SLK 620.49
  - SLK 624
  - SLK625
  - SLK 639
  - SLK 673

  The pits will be approximately 1.2 m deep and the width will vary depending on the availability of material within the area. There will be approximately 900,000 m^3 extracted for base course material. There will be approximately 1,100,000 m^3 extracted for fill material. There will be other pits identified and developed for this project as required. These pits will undergo a separate environmental process using Main Roads CPS 818 state-wide clearing permit.
- Fence lines and associated access tracks which are located 100 m from the centreline of the new road design with a clearing width of six metres (three metres either side).
- Side tracks to maintain traffic flow during construction works

Two construction camps are proposed to be located at SLK 725 and SLK 660 (two hectares each). The camp located (at SLK 660) is outside of the survey area so this location was not assessed during the field survey.

Existing Environment

The desktop and field assessments determined the following environmental aspects associated with the Study Area:

- A review of the ASRIS risk mapping (ASRIS 2013) indicates that the Survey Area is mapped as 'Extremely Low Probability of Occurrence/Very Low Confidence'. A review of the publically available photographs indicates that portions of the road are within ancient floodplains and are potentially vulnerable to inundation or within salt pans. Areas within floodplains and salt pans may present conditions conducive to the formation of ASS, particulary Potential Acid Sulfate Soil (PASS).
- The entire Study Area is within the East Murchison Groundwater Area. Two Public Drinking Water Source Areas, Meekatharra and Wiluna Water Reserves occur within or within proximity to the Study Area; however, neither of these reserves occur within the Impact Area.
- No defined drainage channels or rivers listed under the Rights in Water and Irrigation Act (1914) (RIWI Act) occur within the Survey Area. There are a number of minor drainage channels that intersect the Survey Area including Bubble Creek at the eastern end. No mapped wetlands occur within the Survey Area.
- Broad scale vegetation mapping of the Murchison region by Beard (1974) indicate that eight vegetation associations are present within the Survey Area. The region is largely uncleared and all of these vegetation associations have greater than 97% of their pre-European extent remaining at most levels.

- During the field assessment six structural formations containing 28 vegetation associations (including two disturbance related associations) were identified within the Survey Area and described based on field observations, including:
  - Woodlands (containing six vegetation associations)
  - Tall shrublands (containing 11 vegetation associations)
  - Low shrublands (containing five vegetation associations)
  - Tussock grasslands (containing two vegetation associations)
  - Hummock grasslands (containing two vegetation associations)
  - Disturbed (containing two vegetation associations)
- The majority of the Survey Area was rated as *Excellent* (2) to *Very Good* (3) or *Very Good* (3) (Keighery 1994 scale), with areas in the vicinity of Meekatharra and Wiluna having lower condition ratings due to increased anthropogenic disturbances. Areas of better vegetation condition were generally recorded from breakaways, outcrops and stony hills. Grazing by livestock, native mammals and feral animals has altered vegetation composition across the Survey Area. Grazing and trampling impacts were generally more prevalent within drainage lines and adjacent floodplain areas, as well as the margins of artificial water sources. The most noticeable areas of disturbance throughout the Survey Area included existing borrow pits, pastoral infrastructure (e.g. dams, access tracks, holding yards) and roadside margins.
- No Threatened Ecological Communities were determined to occur, or likely to occur, within the Survey Area. One Priority 1 Priority Ecological Community was recorded within the Survey Area: Calcrete Groundwater Assemblages (CGA). Three CGAs have been mapped as intersecting the Survey Area and a desktop assessment by Subterranean Ecology (2014) determined that numerous additional calcretes occur within the Survey Area which are also likely to harbour CGAs that would qualify for listing as the PEC.
- Two vegetation associations considered to support riparian vegetation were recorded in the Survey Area. These include *Eucalyptus* woodland (VA15) and *Acacia aptaneura* low woodland (VA02) which cover 251.2 ha and 83 ha respectively. Both vegetation associations were restricted to ephemeral drainage lines and adjacent floodplains, and supported riparian taxa.
- The field survey identified vegetation that may be considered as significant due to reasons defined by the EPA (2004a) such as unusual species and a role as a refuge. These vegetation types were restricted to very specific landforms and supported the majority of the priority species recorded in the field survey.
- A total of 398 flora taxa (including subspecies and varieties) representing 53 families and 154 genera were recorded in the Survey Area during the GHD field surveys. This total comprised 391 (98 %) native taxa and seven (2 %) introduced taxa.
- The GHD field survey did not record any flora taxa listed under federal or state legislation within the Survey Area, however, nine Department of Parks and Wildlife (DPaW) Priority-listed flora taxa were recorded: *Eremophila congesta* (Priority 1), *Calytrix uncinata* (Priority 3), *Calytrix verruculosa* (Priority 3), *Gunniopsis propinqua* (Priority 3), *Homalocalyx echinulatus* (Priority 3), *Indigofera* sp. Gilesii (M.E. Trudgen 15869) (Priority 3) ,*Ptilotus luteolus* (Priority 3), *Sauropus ramosissimus* (Priority 3), *Stackhousia clementii* (Priority 3).
- During the field assessment eight broad fauna habitat types were identified in the Survey Area, including:

  - *Acacia* shrubland over tussock grasses
  - *Acacia* shrubland over hummock grasses
  - Mixed shrubland
  - Tussock grassland
  - Chenopod shrubland
  - *Eucalyptus*/*Corymbia* woodland (including riparian habitat around Bubble Creek)
  - Rocky outcrops, breakaways and Banded Ironstone Formation (BIF) hills
  - Sand dune
- The structure and condition of the fauna habitat types varied depending on the level of impact from various disturbances including cattle grazing, fire and past clearing. The most dominant habitat type throughout the Survey Area was *Acacia* shrublands.
- A total of 102 fauna species, consisting of 63 birds, 19 reptiles, 19 mammals and one amphibian were recorded within the Survey Area during the Spring field survey. Of these, seven are introduced (feral) species.
- The GHD field survey recorded five conservation significant fauna species, including one listed as Threatened under Schedule 1 of the *Wildlife Conservation Act 1950* (WC Act), the Grey Falcon (*Falco hypoleucos*), and one migratory species listed under Schedule 3 of the WC Act and as Migratory under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), the Rainbow Bee-eater (*Merops ornatus*). In addition three DPaW Priority-listed fauna species were recorded: the Australian Bustard (*Ardeotis australis*), the Bush Stone-curlew (*Burhinus grallarius*) and the Brush-tailed Mulgara (*Dasycercus blythi*).
- The Survey Area traverses a number of different land tenures including leasehold for pastoralism, leasehold for conservation and road reserve. The dominant landuse on these leases is livestock (cattle) grazing of native pastures. In a number of areas the existing road is not within the road reserve, this is due to historical inaccuracy when converting from hand written records to digitalisation and is being rectified as part of the project. The Survey Area does not intersect any conservation reserves, however, Mooloogool pastoral station, which was relinquished to DPaW and destocked in the early 2000s is a proposed conservation area. Mooloogool Station holds no reservation status at this time.
- No European heritage sites were identified within the Survey Area.

Potential Impacts

Potential impacts identified in this EIA associated with the Project include:

- The Project will involve activities that have the potential to impact surface water hydrology, including:
  - Changes to land topography that modifies overland flow patterns
  - Development of infrastructure that modifies overland flow patterns
  - Interruption to existing surface water flow patterns
  - Increased erosion and sedimentation
  - Contamination of surface water by chemicals and hydrocarbons

However, these potential impacts can be managed by appropriate management measures.

- Clearing of the Impact Area would result in clearing of less than 0.2 per cent of the remaining extent of Beard's (1974) vegetation association at all levels. The clearing required for the Project is therefore unlikely to have a significant impact on the regional vegetation extents.
- The 'other significant vegetation' types that were mapped during the field survey were generally restricted to very specific landforms and the Impact Area avoids impacting on the majority of them. The Project will impact on less than 5 % of each of the 'other significant vegetation' mapped within the Survey Area.
- Clearing of the Impact Area would result in impacts on two Priority 3 flora taxa: *Ptilotus luteolus* (two plants recorded within the Impact Area) and *Stackhousia clementii* (counts averaging 180 individuals per 100 m^2 within the Impact Area).
- There is potential to introduce and/or spread weed species into adjacent areas during the operational phase. The Project has the potential to:
  - Increase the spread of weeds along the highway
  - Introduce new weed species into the area through construction traffic and soil movement
  - Introduce weeds into areas in which they did not previously occur (particularly relevant for the borrow pit areas)

  However, the risk of introduction of weed species is an existing issue in the area due to the extensive disturbance from traffic and cattle. The spread of weed species is not expected to significantly increase as a result of the Project and the implementation of weed management measures should assist in minimising the risk of potential environmental impacts.
- Subterranean Ecology (2014) determined that there is no existing evidence and a low likelihood that the proposed Project actions will pose a threat to Calcrete Groundwater Assemblages (CGAs) subject to the following assumptions:
  - Groundwater pumping or drawdown will not impinge on any CGAs
  - Best practice operational procedures are applied to avoid and manage potential impacts to groundwater recharge and groundwater quality that might result from road building activities on or near to CGAs including drainage, gravel pits and control of leakage/spills.

  Subterranean Ecology recommend modelling of the lateral extent of the drawdown propagation to ensure 2,000 m buffer (of zero drawdown) separation from any calcrete deposit. Where there is a likelihood that a CGA or other calcrete deposit may be affected by the Project then it is recommended that field inspection by a suitably qualified person be undertaken to confirm that sites selected for groundwater abstraction and gravel pits are located to avoid calcrete (Subterranean Ecology 2014).
- Clearing of the Impact Area would result in clearing of 510.4 ha of fauna habitat associated with remnant vegetation, and therefore result in a loss of the habitat available to fauna species.
- In addition to the loss of habitat, the project may potentially result in specific impacts to conservation significant fauna species, including those identified as known to, likely to or which may possibly occur in the proposed Impact Area. These potential impacts include:

  - Loss of 122.3 ha of known habitat for the Brush-tailed Mulgara.
  - Increased risk of death or injury for the Malleefowl and Brush-tailed Mulgara due to vehicle strike during the construction and ongoing phases of the proposed. While Malleefowl were not recorded during the field survey, the species is known to occur in the region and is susceptible to vehicle strike during both phases of the project. The Brush-tailed Mulgara is particularly susceptible to vehicle strike during the construction phase, given the proximity of active burrows to the Impact Area recorded during the field survey.

- The Impact Area is outside the existing designated road reserve for much of its length. Therefore due process must be followed to secure the new road within the appropriate road reserve. The Project consists of upgrading an existing road and temporary usage of areas as borrow pits and camps. These land use activities are not considered likely to significantly impact on the current landuse of the area, which is broadscale grazing.
- There is a minor risk that the construction works will create temporary or localised pollution as a result of fuel or chemical spills or mismanagement of construction materials. This risk is low and will be managed through appropriate management measures and auditing.
- Construction dust emissions are expected to occur through earthworks and wind erosion. The closest residential receptors to the road alignment are located in Meekatharra, approximately 100 m away. All other receptors are greater than 100 m. Dust impacts at receptors 100 m or further from the site are expected to be minor and will be considered during the construction phase.
- Given the distances involved between site works and the nearest receptors, vibration impacts from construction or operation affecting human comfort and building integrity are not expected to be significant.

Additional actions and referrals

Further assessment or approvals recommended include:

- The relevant land authorities should be consulted to determine the appropriate process to follow to allow for changes in the purpose and vesting of the land.
- Consultation with pastoral leaseholders is recommended as a matter of courtesy and to determine any potential concerns or issues such as impact on access or fencelines due to the Project.
- Aboriginal heritage has not been considered as part of this EIA and an Aboriginal heritage assessment will be required
- The EMP should be implemented during the design, construction and operational phases of the project.
- Further assessment on the PEC Concrete Groundwater Assemblages may be required.
- Unless the Project is assessed by the Environmental Protection Authority a clearing permit will be required. Due the the size of the Project it will not be assessed under the CPS 818/11. Main Roads will need to apply for a separate clearing permit.

This Project is unlikely to require referral to the Department of the Environment under the *Environment Protection and Biodiversity Conservation Act 1999* as no Matters of National Environmental Significance (MNES) will be triggered.

This EIA has found the Project will have minimal adverse impacts to the surrounding environment, will only be associated with localised increases in emissions during construction, and is not likely to have a high level of public interest. The majority of the environmental impacts associated with the Project are linked to vegetation clearing and loss of fauna habitat. These potential impacts and proposed mitigation actions (and offsets, if required) for the Project can be effectively regulated through the Environmental Protection (Clearing of Native Vegetation) Regulations 2004. Therefore, it is considered the Project is unlikely to require referral to the Environmental Protection Authority under Section 38 of the *Environmental Protection Act 1986*.

A project specific Environmental Management Plan (EMP) should be implemented to manage environmental impacts associated with the project. The EMP should include management measures to:

- Minimise clearing of vegetation through the design and construction process and prevent unauthorised clearing
- Minimise the risk of erosion through design and construction processes
- Manage any contamination identified during works
- Control dust generation including standard dust suppression techniques such as the use of water carts
- Manage pollution generating activities such as refuelling or storage of chemicals during works
- Manage hazardous substances on site in accordance with material safety data sheets
- Control the introduction or spread of Declared Plants.

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1. Introduction

1.1 Project background

Goldfields Highway extends almost 800 kilometres (km) from south of Kambalda in the Goldfields, to Meekatharra, in Western Australia's Mid-West. The section of Goldfields Highway between Wiluna and Meekatharra is approximately 182 km in length and is a key route that links industry and community between the Goldfields-Esperance region and the Mid-West / Pilbara regions.

The route provides for the established, shared relationships and services between Wiluna and Meekatharra, servicing of mining, pastoral and tourism industries and people living locally in remote communities in the north east Goldfields region. Main Roads WA have indicated that from time to time safety and serviceability concerns are raised in respect to dust, the road surface and serviceability of the flood crossings, particularly from flood and storm events, which can result in disruption to travel and periods of road closure.

A total of 35 km of the Goldfields Highway between Wiluna and Meekatharra is currently sealed to provide overtaking opportunities and to help manage flooding and road closures at flood-ways. The remaining 145 km of road is unsealed but has been sheeted to maintain a running surface. Of the 35 km that is sealed, only a 15 km section near Wiluna has been built to acceptable geometric standards. The remaining 20 km is low level formation that has been sealed to improve safety (passing opportunities) and preserve scarce road building materials.

Providing a road that is sealed, more direct and efficient to connect the regions, has been a focus of discussion in the transport and resources industry for many years. The concept is being promoted by the Department of Lands (DL), Development Commissions and other government agencies through the PortLink Inland Freight Corridor Development Plan (PortLink Plan).

The PortLink concept ultimately links ports in the Pilbara, Midwest and Goldfields-Esperance regions through providing better transport structure and services to stimulate investment in regions and local economies. One of the projects in Phase 1 of PortLink is project development work for the sealing of the Wiluna to Meekatharra Road (Goldfields Highway) (the Project). A sealed road between the two towns would provide a distance saving of more than 140 km, in comparison to driving the existing sealed route via Goldfields Highway/Mount Magnet-Leinster Rd and Great Northern Highway.

1.2 Existing and proposed works

Main Roads WA Mid-West Region is in the process of implementing a design and construct alliance (SafeLinks) contract for the 'improvement works' of four sections of upgrading and sealing to highway standard along this section of Goldfields Highway. These identified sections range from 4.5 km to 10.5 km in length with the outcome of distances between sealed portions being less than 20 km. This will result in a further 25 km formed and sealed to highway standard.

The existing works being undertaken on the Goldfields Highway as well as the areas that are included in the scope of this Project are detailed in Table 1.

Table 1 Existing works and those included within the current Project

SLK Start	SLK End	Distance	Design/Formation	Included within Current Project
608.38	618.2	4.94	Currently unsealed	Yes
618.2	625.93	7.73	Formed and sealed to highway standard	No
625.96	635.77	9.81	Currently unsealed	Yes
635.77	642.78	7.01	Formed and sealed to highway standard	No
642.78	647.6	4.82	Currently unsealed	Yes
647.6	653.95	6.35	Sealed; however not to highway standard	Yes
653.95	685.1	31.15	Predominantly unsealed	Yes
685.1	689.6	4.5	Unsealed	No - included in SafeLinks
689.6	703.94	14.34	Predominantly unsealed	Yes
703.94	714.7	10.76	Unsealed	No - included in SafeLinks
714.7	749	34.3	Predominantly unsealed	Yes
749	753.6	4.6	Unsealed	No - included in SafeLinks
753.6	767.5	13.9	Predominantly unsealed	Yes
767.5	772.6	5.1	Unsealed	No - included in SafeLinks
772.6	793.28	20.68	Predominantly unsealed	Yes

1.3 Description of the proposal

Main Roads WA commissioned GHD Pty Ltd (GHD) to prepare an Environmental Impact Assessment (EIA) and Environmental Management Plan (EMP) for the Project. This EIA and EMP will be used to identify, assess and manage the anticipated environmental impacts associated with the Project.

The overall Project involves the investigation, design and construction of the Goldfields Highway Wiluna to Meekatharra Section. Main Roads proposes to upgrade this section to highway standard. The Project will include the following components:

- 145km of resealing works
- ~ 18 km of minor re-alignment, raising and sealing of the road
- Six Intersection upgrades
- Drainage improvements including floodways and levees
- ~220 km of fencing
- Eight material pit extraction sites
- Side tracks to maintain traffic flow during construction works
- Two construction camps

1.4 Project location

The Project is located in the Mid-West region of Western Australia, within the Shires of Wiluna and Meekatharra. The desktop assessment considered a wider area than that of the field assessment. A description of the different areas assessed for the different components is provided in Sections 1.4.1 to 1.4.3.

1.4.1 Study Area

The Study Area extends 180 km from Wiluna (SLK 613.28) to Meekatharra (SLK 793.28) and includes a 100 km buffer (i.e. 50 km either side) centred on the existing Goldfields Highway. The Study Area was used for the desktop assessment.

1.4.2 Survey Area

The Survey Area extends 180 km from Wiluna (SLK 613.28) to Meekatharra (SLK 793.28) and includes a one kilometre buffer (i.e. 500 metres (m) either side) centred on the Goldfields Highway. The Survey Area covers 17,962 hectares (ha). The Survey Area was used for the field assessment and is mapped in Figure 1.

1.4.3 Impact Area

The proposed Impact Area is the area that will be potentially impacted by the Project. The impact assessment was conducted on the Impact Area. The proposed Impact Area is 534 ha and includes:

- Areas of road upgrade and realignment minus the existing road, where it overlaps
- Drainage levees
- Eight material pits and access tracks at:
  - SLK 614 (1)
  - SLK 614 (2)
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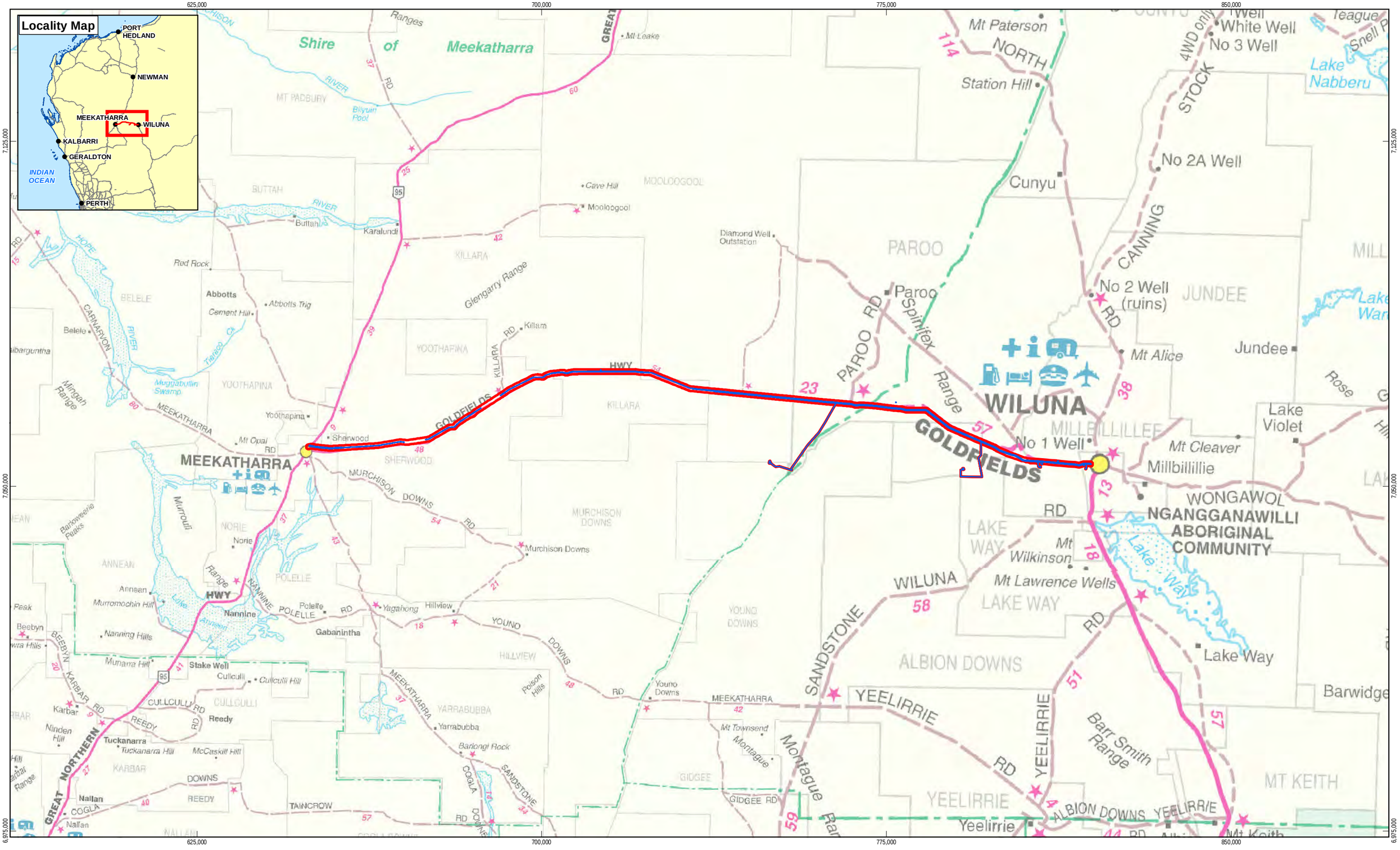
  The pits will be approximately 1.2 m deep and the width will vary depending on the availability of material within the area. There will be approximately 900,000 m^3 extracted for base course material. There will be approximately 1,100,000 m^3 extracted for fill material. There will be other pits identified and developed for this project as required. These pits will undergo a separate environmental process using Main Roads CPS 818 state-wide clearing permit.
- Fence lines and associated access tracks which are located 100m from the centreline of the new road design with a clearing width of six metres (three metres either side).
- Side tracks to maintain traffic flow during construction works
- Two construction camps are proposed to be located at SLK 725 and SLK 660 (size 2 ha each). The camp located at SLK 660 is outside of the survey area so this location was not assessed during the field survey.



Legend

- Impact Area
- Survey Area

Main Roads Western Australia
EIA and EMP for
Goldfields Highway Project

Job Number	61-30097
Revision	0
Date	16 Sep 2014

Locality

Figure 1

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Data source: GHD: Survey Area - 20141016; GA: 250k Topo Series 3 2006 - 20140611; Landgate: Travellers Atlas - 20140611

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1.5 Scope of works

GHD's scope of work for the EIA component was to:

- Describe the existing environment associated with the Study area
- Undertake a Level 2 vegetation and flora and Level 1 fauna survey to inform the EIA
- Undertake an environmental impact assessment of the Project, describing the potential impacts on the existing environment
- Identify key environmental aspects for further environmental investigation
- Identify and recommend potential locations for temporary infrastructure required
- Identify and recommend potential regulatory approvals required

GHD's scope of work for the EMP component was to:

- Recommend environmental management actions in accordance with conclusions of the EIA report
- Identify roles and responsibilities for EMP implementation
- Suggest a monitoring and maintenance program to assess the implementation of this EMP

Aboriginal heritage assessment was not included as part of the Scope of Works for this Project as it is being conducted in a separate assessment.

1.6 Information sources

A number of information sources were used to identify the existing environment surrounding the Project and potential impacts associated with Project development. Collated information sources are presented in Table 2.

An overview of key legislation and guidelines, conservation codes and background information relevant to this Project is provided in Appendix A. Detailed methods associated with the field assessment for this Project are described in Appendix B. The results of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Protected Matters Search Tool (PMST) and Department of Parks and Wildlife (DPaW) *NatureMap* database searches are presented in Appendix C. Other than the database searches, no other environmental agencies were consulted during the preparation of this EIA and EMP.

Table 2 Information sources

Aspect	Information Source
Climate	Climatic data available from the Bureau of Meteorology (BoM 2013a, 2013b)
Matters of National Environmental Significance	Search of the EPBC Act PMST for Matters of National Environmental Significance in the Study area (DotE 2013d)
Geology, topography, soils and land systems	Geology, topography, soils and land systems in the Survey Area as described in Mabbutt *et al*. (1963)
Hydrology	Assessment of the surface and groundwater features in the Study area based on: • Department of Water (DoW) Geographic Data Atlas (DoW 2013) • DPaW *WetlandBase* (DPaW 2013b) • EPBC Act PMST (DotE 2013d)
Reserves	Reserves for conservation as shown in DPaW Managed Lands and Waters spatial dataset (GoWA 2012)

Aspect	Information Source
Environmentally Sensitive Areas	Identification of Environmentally Sensitive Areas utilising Clearing Regulations – Environmentally Sensitive Areas (ESA) spatial dataset (GoWA 2012) Native Vegetation Map Viewer (DEC 2013c)
Regional biogeography	Regional biogeographical information for the Survey Area as described in: • Australia's bioregions (IBRA) (DotE 2013e) • Cowan (2001) • Desmond et al. (2001) • McKenzie et al. (2002)
Vegetation	Vegetation in the Survey Area as show in: • Beard Vegetation Mapping (1974) • Flora and vegetation assessment undertaken by GHD (methodology detailed in Appendix B)
Threatened and Priority Ecological Communities	Ecological communities listed in the following databases as being within the Study area: • DPaW Threatened Ecological Community (TEC) and Priority Ecological Community (PEC) spatial datasets • DPaW PEC List (DEC 2013a) • TECs endorsed by the Minister for Environment (DEC 2013b) • Vegetation and flora field survey undertaken by GHD (methodology detailed in Appendix B) • Desktop assessment of stygofauna PECs by Subterranean Ecology (2014) (Appendix E)
Conservation Significant Flora and Fauna	Conservation significant flora and fauna listed in the following databases as being within the Study area: • DPaW NatureMap (DPaW 2007–) • DPaW Threatened (Rare) and Priority Flora database (TPFL) and Western Australian Herbarium database (WAHERB) • DPaW Threatened and Priority Fauna datasets • Vegetation, flora and fauna field assessment undertaken by GHD (methodology detailed in Appendix B)
Acid Sulfate Soils	Acid Sulfate Soils (ASS) Risk Mapping prepared from: • Australia Soil Resources Information System (ASRIS 2013)
Contaminated sites	Identification of potentially contaminated sites utilising: • DPaW Contaminated Sites Database (DPaW 2013a)
European Heritage	Identification of European heritage sites utilising: • DotE Australian Heritage Database (DotE 2013a) • EPBC Act PMST (DotE 2013d) • Government of Western Australia Inherit Database (GoWA 2013a)

1.7 Relevant legislation

There is a range of Federal and State legislation and guidelines that relate to this EIA/EMP. An outline of key relevant legislation and guidelines is provided in Table 3.

Table 3 Relevant environmental legislation and guidelines

Legislation / Guideline	Responsible Agency	Aspect / Application
Commonwealth		
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)	Department of the Environment	Protection of matters of national environmental significance; assessments on Commonwealth land.
State		
Biosecurity and Agriculture Management Act 2007 (BAM Act)	Department of Agriculture and Food Western Australia	Outlines Declared pests which are nominated by DAFWA as organisms that are, or may become, a problem to the environment.
Conservation and Land Management Act 1984 (CALM Act)	Department of Parks and Wildlife	Provides for the better protection and management of certain public lands and waters, and the flora and fauna thereof.
Wildlife Conservation Act 1950 (WC Act)	Department of Parks and Wildlife	Provides for the conservation and protection of wildlife (flora and fauna). Special provisions and schedules cover protection and management of gazetted rare flora and fauna.
Environmental Protection Act 1986 (EP Act)	Environmental Protection Authority & Department of Environmental Regulation	Prevention, control and abatement of pollution and environmental harm, for the conservation, preservation, protection, enhancement and management of the environment and for related. Referral of proposals Clearing permits and works approval
Environmental Protection (Clearing of Native Vegetation) Regulations 2004	Department of Environmental Regulation	Regulates the clearing of native vegetation.
Heritage of Western Australia Act 1990	Heritage Council	Provides for and encourages the conservation of places with cultural heritage significance to Western Australia.
Rights in Water and Irrigation Act 1914 (RIWI Act)	Department of Water	Management of water in Western Australia.
Draft Technical Guide – Flora and Vegetation Surveys for Environmental Impact Assessment (EPA & DEC 2012)	Environmental Protection Authority & Department of Parks and Wildlife	Provides guidance and information on expected standards and protocols for terrestrial flora and vegetation surveys to environmental consultants and proponents.
Guidance Statement No. 51 – Guidance for the Assessment of Environmental Factors: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia. (EPA 2004a)	Environmental Protection Authority	Provides guidance and information on expected standards and protocols for terrestrial flora and vegetation surveys to environmental consultants and proponents.

Legislation / Guideline	Responsible Agency	Aspect / Application
Guidance Statement No. 56 – Guidance for the Assessment of Environmental Factors: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia. (EPA 2004b)	Environmental Protection Authority	Provides guidance and information on expected standards and protocols for terrestrial fauna surveys to environmental consultants and proponents.
Position Statement No. 3 – Terrestrial Biological Surveys as an Element of Biodiversity Protection. (EPA 2002)	Environmental Protection Authority	Outlines the principles in relation to the provision of information in the assessment of biodiversity.
Technical Guide for Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment (EPA & DEC 2010)	Environmental Protection Authority & Department of Parks and Wildlife	Provides guidance and information on expected standards and protocols for terrestrial fauna surveys to environmental consultants and proponents.

1.8 Limitations and assumptions

This report has been prepared by GHD for Main Roads Western Australia and may only be used and relied on by Main Roads Western Australia for the purpose agreed between GHD and Main Roads Western Australia as set out in Section 1.5 of this report.

GHD otherwise disclaims responsibility to any person other than Main Roads Western Australia arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section(s) 1.5 and 1.8 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Main Roads Western Australia and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of buildings, services and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

Site conditions (including the presence of hazardous substances and/or site contamination) may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.

It should be noted that the flora and fauna survey is based upon the Survey Area shown in Figure 1, and further assessment would be required should the Survey Area significantly change.

Indigenous heritage issues have not been covered in this report and as it is understood that separate indigenous heritage assessments have been commissioned by Main Roads.

This EIA has not considered impacts from potential groundwater extraction that may be required for this Project.

2. Existing Environment

2.1 Climate

The Mid West region of Western Australia experiences a variety of climatic conditions. The coastal areas of the region have a mild Mediterranean climate with hot/dry summers and mild/wet winters, while the inland areas experience arid climatic conditions with very hot/dry summers and cold/dry winters. There is a transitional zone between these two areas which experiences a semi-arid climate.

The climate at Meekatharra is semi-arid with high summer temperatures. The rainfall is highly erratic with a long term average of 237 mm per annum. The average annual potential evaporation is more than 10 times the annual rainfall (BoM 2013a). Wiluna experiences a semi-arid climate with very irregular rainfall averaging 258 mm per annum. Most rainfall occurs in January to May, coming from summer cyclonic rains and isolated thunderstorms (BoM 2013b).

The two closest Bureau of Meteorology (BoM) weather recording stations to the Study area are located at Meekatharra Airport (station number 7045, BoM 2013a) and Wiluna (station number 13012, BoM 2013b). A summary of the climatic data (BoM 2013a, b) for these weather stations are presented in Plate 1.

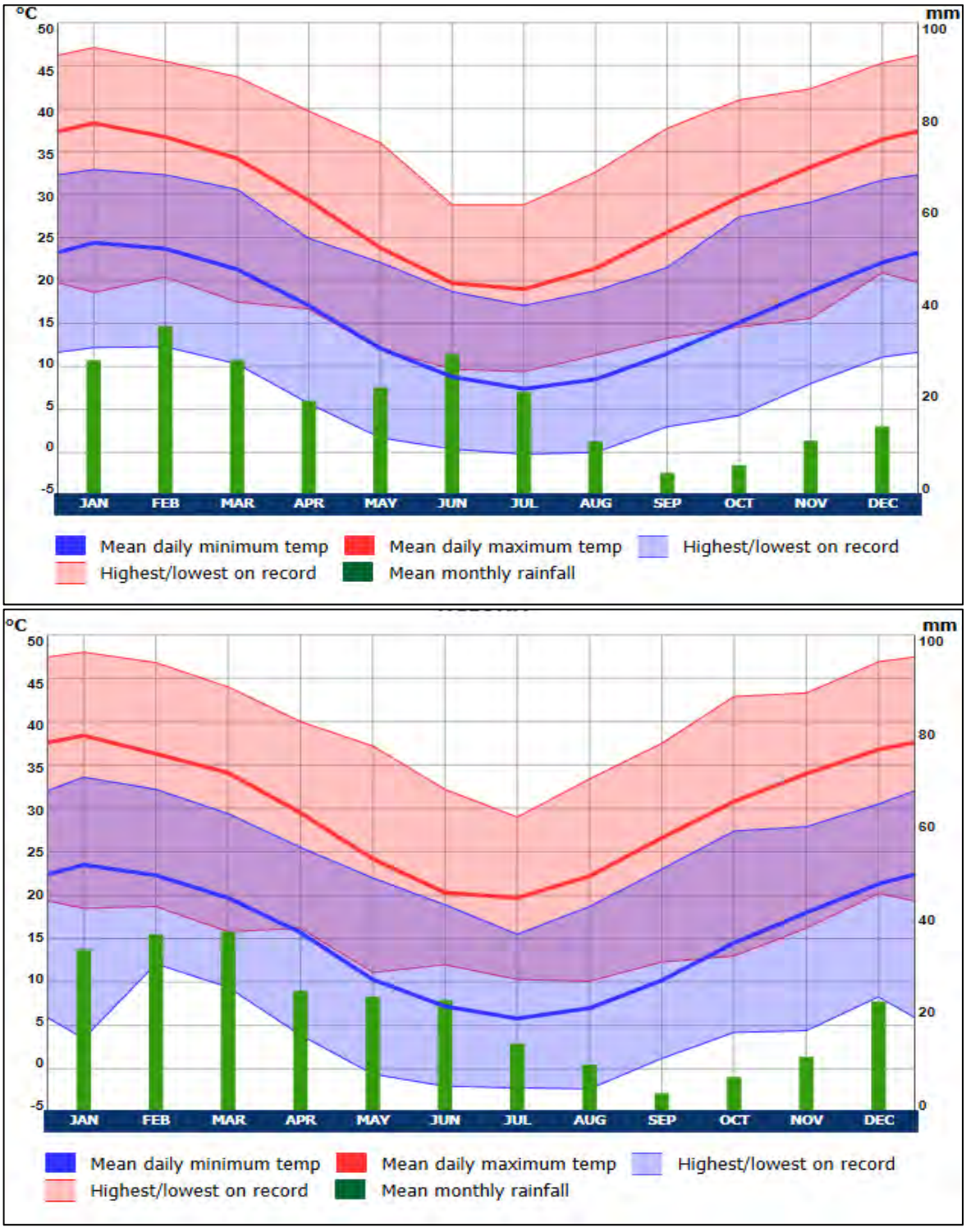


Plate 1 Climatic data for Meekatharra Airport (years 1944 to 2013) and Wiluna (years 1898 to 2013) (BoM 2013a, b)

2.2 Geology, soils and topography

2.2.1 Geology

The Wiluna-Meekatharra area forms part of the Western Australian Pre-Cambrian shield and includes portions of the Murchison, East Murchison and Mt. Margaret goldfields. Most of the area is underlain by Archean gneiss and granite traversed by remnant belts of steeply dipping metavolcanic greenstone and metasedimentary whitestone (Mabbutt *et al.* 1963). The greenstone, which is mainly schistose, consists predominantly of lava, tuff and agglomerate, with minor intercalation of metasedimentary lenses, ultrabasic intrusive and acid volcanics. The whitestone comprises a wide variety of schists diversified by resistant jaspilite and quartzite. Proterozoic lavas and sediments (Nullagine "system") were laid down unconformably in shallow basins on the crystalline basement in the normal central and north-east parts of the area (Mabbutt *et al.* 1963).

The Wiluna-Meekatharra area has remained land since the Palaeozoic time and has undergone no significant deformation. Over much of the area the rocks described above bear remnants of ferruginous and siliceous cappings inherited from a Tertiary phase of deep weathering (Mabbutt *et al.* 1963).

The Meekatharra area is located on the northern extent of the Yilgarn Craton within the Meekatharra – Mt Magnet greenstone belt. The basement rock is overlain with large areas of laterite, however in some areas this laterite has been eroded along current and historical drainage lines. In these areas, the basal rock has been overlain by colluvial and alluvial deposits of sand and clay up to 20 metres thick (Water and Rivers Commission 2001).

2.2.2 Soils

The soils of the Wiluna-Meekatharra area are generally leached in nature and have widespread siliceous hard-pan or "cement" (Mabbutt *et al.* 1963). Apart from this hard-pan, the soils of the area resemble those of other parts of arid Australia. Leached course-grained red earths and red sands are the most extensive soils and are mainly derived from weathered rock on the old plateau. Shallow red-earths with massive hard-pan mainly occur on tributary alluvial plains, whilst lower floodplains also have calcareous and saline soils. Soils derived from fresh rock material occur in a small extent, and weathering crusts and weathered rock surfaces are widespread (Mabbutt *et al.* 1963).

Seven soil groups have been defined throughout the Meekatharra-Wiluna area, including: alluvial soils, shallow and stony soils, red and clayey sands, red earths, calcareous earths, textured contrast soils and red coarse-structured clays (Mabbutt *et al.* 1963).

2.2.3 Acid sulfate soils

The section of the Goldfields Highway between Meekatharra and Wiluna lies on the interior plateau of Western Australia. Much of the region is covered by an ancient erosion surface, now represented by extensive sheets of eolian sand with longitudinal dunes. The highway route tends to pass over red-brown eolian sands, colluvium, alluvium, and valley calcrete. Topographical elevations for the site range between 520 m AHD at Meekatharra and 510 m AHD at Wiluna to a regional high point of 600 m AHD.

A review of the ASRIS risk mapping (ASRIS 2013) indicates that the Survey Area is mapped as 'Extremely Low Probability of Occurrence/Very Low Confidence'. The confidence level for this mapping is a provisional classification inferred from surrogate data with no on ground verification (ASRIS 2013).The ASS risk mapping classifications are considered consistent with published geological information.

Published available information for the Goldfields Highway between Meekatharra and Wiluna dates back to 2001. A review of the publically available photographs indicates that portions of the road are within ancient floodplains and are potentially vulnerable to inundation. Moreover, there are a number of salt pans within the vicinity of the road reserve (at chainage 726). Areas within floodplains and salt pans may present conditions conducive to the formation of ASS, particularly Potential Acid Sulfate Soil (PASS).

2.3 Land systems

The Wiluna-Meekatharra area has been surveyed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Western Australian Department of Agriculture and Food (DAFWA), Department of Environment and Conservation (DEC) (now DPaW) and Landgate for the purposes of land classification, mapping and resource evaluation. The Survey Area is located within 13 land systems; details of these land systems are presented in Table 4 (Mabbutt *et al*. 1963).

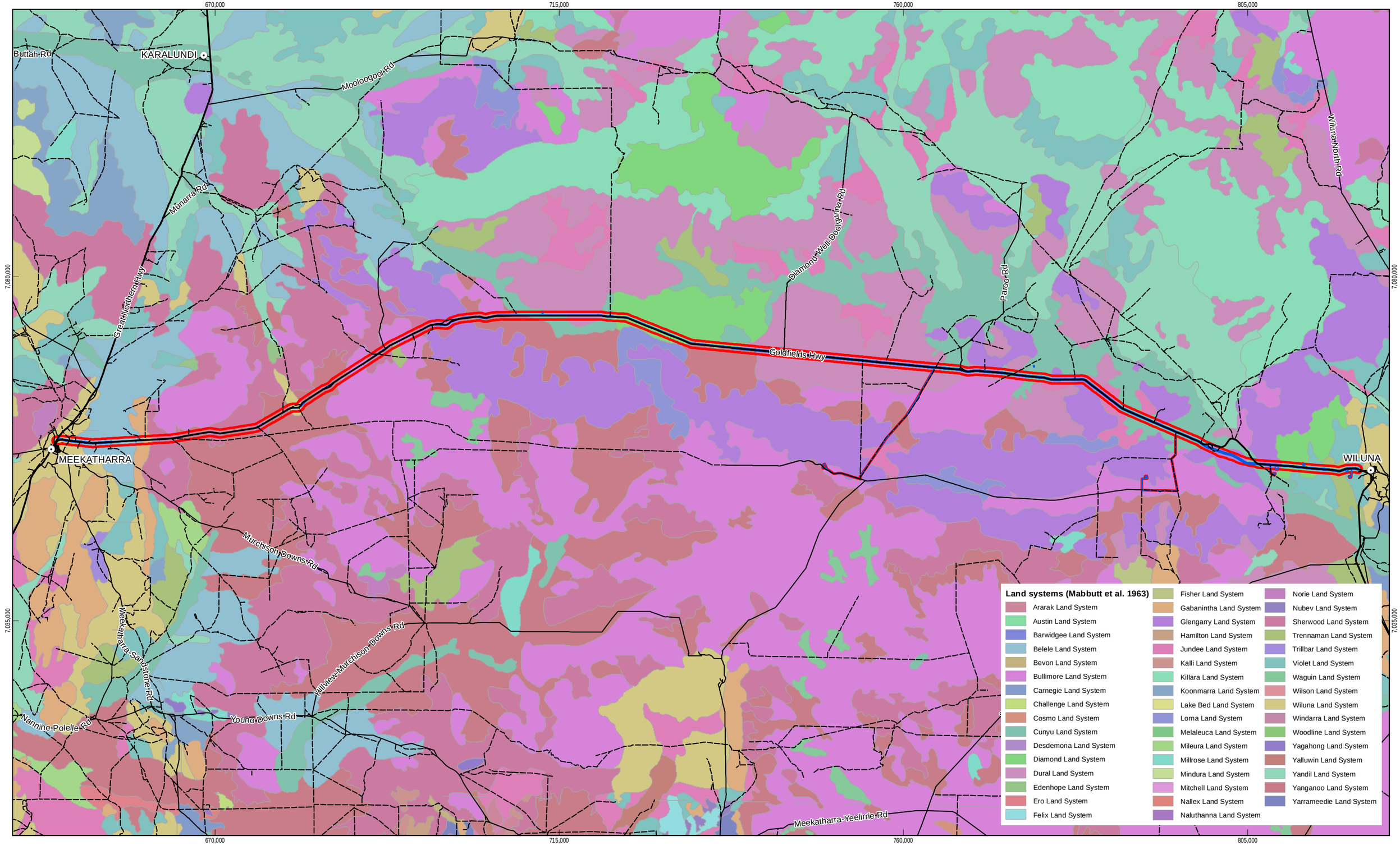
Table 4 Details of land systems found in the Survey Area (Mabbutt *et al.* 1963)

Land System	Location in Survey Area	Description	Geology	Geomorphology
Wiluna Land System	Western end near Meekatharra between SLK 791-793 and around SLK 761	Low greenstone hills with occasional lateritic breakaways and broad stony slopes, lower saline stony plains and broad drainage tracts; supporting sparse mulga and other acacia shrublands with patches of halophytic shrubs.	Archaean: weathered, steeply dipping metavolcanic and metasedimentary schist with minor hematitc and siliceous jaspilite (greenstone and some whitestone)	Surfaces formed by dissection of the old plateau – low hills: strike belts up to 10 miles wide; dissected higher parts, with minor stable surfaces, rounded hills with laterite cappings, and ridges; undulating lower parts, with stony slopes; fairly dense drainage, with alluvial strike valleys and incised, branching tributaries.
Belele Land System	Western end between SLK 783-790	Hardpan wash plains interspersed by low sandy (wanderrie) banks supporting tall shrublands of mulga with understorey shrubs on the hardpan plains and non-saline shrubs with perennial grasses on the banks.	Quaternary cemented alluvium and Aeolian sand derived mainly from gneiss and granite.	Depositional surfaces – alluvial plains with wind modification: tributary plains, gradients 1 in 250 to 1 in 1000; inter-drainage sectors up to three miles wide, with wanderrie banks and flats, mainly transverse, but also oblique and elongate downslope, and forming connected patterns locally; through-going central drainage plains.
Gabanintha Land System	Western end around SLK 782	Ridges, hills and footslopes of various metamorphosed volcanic rocks (greenstones), supporting sparse acacia and other mainly non-halophytic shrublands.	Selectively weathered, steeply dipping quartz-feldspar schist, basic lava and hematitc and siliceous jaspilite (whitestone and some greenstone) of Archaean age.	Surfaces formed by dissection of the old plateau – mountain and hill ranges: strike belts up to about five miles wide, with rocky jaspilite ridges, rounded crests with laterite cappings, and extensive lower slopes, strike-controlled or rectangular pattern of incised drainage of moderate density.
Sherwood Land System	Western end between SLK 776-781, 772-3, 766-7, 745-749, 739-743	Breakaways, kaolinised footslopes and extensive gently sloping plains on granite supporting mulga shrublands and minor halophytic shrublands.	Weathered and unweathered Archaean gneiss and granite.	Surfaces formed by dissection of the old plateau – breakaways and plains: marginal breakaways formed in mottled zone; escarpments and alluvial fans in or derived from kaolinized rock; stony plains and small hills eroded in little-weathered rock; moderately dense, branching or rectangular. Joint-controlled drainage with prominent alluvial drainage floors.

Land System	Location in Survey Area	Description	Geology	Geomorphology
Yanganoo Land System	Western end between 752-776, 728-736, 697-705	Almost flat hardpan wash plains, with or without small wanderrie banks and weak groving; supporting mulga shrublands and wanderrie grasses on banks.	Quaternary cemented alluvium derived mainly from gneiss, granite, and feldspathic schist; Aeolian sand on margins.	Depositional surfaces – mainly non-saline alluvial plains: lobate upper tributary plains, extending generally less than five miles (approximately eight kilometres) downslope, gradients above 1 in 500; apart from minor feeder drainage zones in upper and inter-lobe sectors, surfaces are subject to sheet-flow margins are commonly transitional to sand plain.
Bullimore Land System	Western end between SLK 742-751 Eastern end around 630	Extensive sand plains supporting spinifex hummock grasslands.	Quaternary Aeolian sand derived mainly from gneiss and granite.	Depositional surfaces – sand plain and dunes: extensive undulating interfluves with little local drainage, consisting mainly of sand plain, with scattered NW trending linear dunes in lower areas.
Trennaman Land System	Western end around SLK 744 Eastern end between SLK 615-617	Sandy hardpan plains and broad drainage zones supporting groved mulga shrublands and wanderrie grasses.	Quaternary cemented alluvium and sand derived mainly from weathered amphiboltic and feldspathic schists and fine-grained sedimentary rock.	Depositional surfaces – mainly non-saline alluvial plains: sandy upper tributary plains occupying lowland embayments and extending up to five miles downslope, gradients 1 in 250 to 1 in 500 inter-drainage sectors with wanderrie tracts, separated by zones of more active sheet-flow with vegetation groves; central drainage plains, locally with channels.
Glengarry Land System	Western end between SLK 736-739, 652-658 Eastern end between SLK 624-626	Sandstone plateaux, summits and hillslopes supporting mainly dense mulga and other acacia shrublands, spinifex, and numerous low shrubs.	Partly weathered, gently dipping Upper Proterozoic sandstone and quartzite, with interbedded mudstone and shale, and dolomite.	Surfaces formed by dissection of the old plateau – sandstone plateaux, bevelled ridges and small hills, with steep rocky slopes and minor lowland tracts, forming dissected watersheds up to 10 miles wide in centre of area; incised moderately dense, strike-controlled drainage.

Land System	Location in Survey Area	Description	Geology	Geomorphology
Cunyu Land System	Central section between SLK 722-727, 716, 671-2, 658-664 Eastern end between SLK 626-648	Calcrete platforms and intervening alluvial floors and minor areas of alluvial plains, including channels with acacia shrublands and minor halophytic shrublands.	Tertiary calcrete with opaline silica and fine gravel at depth, partly overlain by cemented Quaternary alluvium.	Depositional surfaces – calcreted valley fills: up to five miles wide, was a mosaic of calcrete platforms up to 15 ft high, and narrow intervening alluvial floors; broader alluvial plains on outer margins, locally burying the calcrete; restricted channel drainage
Dural Land System	Central section between SLK 717-722, 665-696 Eastern around SLK 631	Strongly undulating terrain on weathered mudstone and basalt supporting open mulga shrublands with mallee and spinifex.	Weathered, gently dipping basalt and interbedded mudstone, shale, and sandstone of Upper Proterozoic age (Nullagine “system”)	Undulating terrain forming part of the old plateaus: strongly undulating tracts with rounded stable crests and lightly stripped slopes, with rockier areas on sandstone; diffuse pattern of shallow upper valleys, and branching alluvial trains elsewhere; drainage floors and minor channels in areas of through-going drainage or stronger dissection.
Diamond Land System	Central section between SLK 699-716 Eastern end between SLK 620-623	Gently undulating plains supporting sometimes groved mulga tall shrublands with dense low shrubs.	Weathered, gently dipping basalt and interbedded mudstone and shale of Upper Proterozoic age (Nullagine “system”)	Undulating terrain forming part of the old plateaus: very gently undulating watersheds of moderate extent; rounded, stable crests and lightly stripped lower slopes, with a sparse branching pattern of unchannelled, shallow valleys
Jundee Land System	Central section between SLK 655-658 Eastern end between SLK 648-651	Hardpan plains with ironstone gravel mantles and occasional sandy banks supporting mulga shrublands.	Cemented Quaternary alluvium derived mainly from fine-grained lava and mudstone.	Depositional surfaces – mainly non saline alluvial plains: stony upper tributary plains, extending mainly less than five miles downslope, gradients 1 in 200 to 1 in 500; multiple lobes up to 1.5 miles wide with thin vegetation groves and transverse or elongate sand banks in lower sectors, separated by channelled drainage tracts which open into wider flood-plains downslope.

Land System	Location in Survey Area	Description	Geology	Geomorphology
Violet Land System	Eastern end near Wiluna, between SLK 617-619, 613-615	Gently undulating gravelly plains on greenstone, laterite and hardpan, with low stony rises and minor saline plains; supporting groved mulga and bowgada shrublands and patchy halophytic shrublands.	Weathered, steeply dipping, Archaean basic schist (greenstone) and gently dipping Upper Proterozoic basalt (Nullagine “system”)	Surfaces formed by dissection of the old plateau – breakaways and plains: gently rounded, stable or lightly stripped crests and extensive lower slopes; sparse pattern of parallel, through-going alluvial drainage floors; little channel drainage except in uppermost sectors.



1: 450,000 (at A3)

0 5 10 15 20 25

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

LEGEND

- Localities
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

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Land systems

Figure 2

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Data source: DAFWA: Land Systems, 2010; Landgate: Roads - 20140611; GHD: Study Area, Impact Area - 20140617. Created by: ES

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2.4 Hydrology

A search of the Department of Water (DoW) Geographic Data Atlas (DoW 2013) indicated that the Study Area is within the Murchison River and Salt Lake Catchment Basins. A summary of the Geographic Data Atlas queries for the Study Area is provided in Table 5. Two proclaimed areas were identified within the Study Area.

Table 5 Department of Water geographic atlas queries for the Study Area (DoW 2013)

Aspect	Details	Result
RIWI Groundwater Areas	Groundwater areas proclaimed under the *RIWI Act 1914*.	East Murchison
RIWI Surface Water Areas	Surface water areas proclaimed under the *RIWI Act 1914*.	None present
RIWI Irrigation District	Irrigation Districts proclaimed under the *RIWI Act 1914*.	None present
RIWI Rivers	Rivers proclaimed under the *RIWI Act 1914.*	None present
Public Drinking Water Source Areas (PDWSA)	PDWSAs is a collective term used for the description of Water Reserves, Catchment Areas and Underground Pollution Control Areas declared (gazetted) under the provisions of the *Metropolitan Water Supply, Sewage and Drainage Act 1909* or the *Country Area Water Supply Act 1947*.	Meekatharra Water Reserve
Waterway Management Areas	Areas proclaimed under the *Waterway Conservation Act 1976*.	None present

2.4.1 Groundwater

A search of the DoW Geographic Data Atlas (DoW 2013) indicated that the entire Study Area is within the East Murchison Groundwater Area (Figure 3). These groundwater areas are protected under the RIWI Act and a permit will be required if groundwater abstraction is necessary for the Project.

A search of the DoW Water Information Reporting (WIR) registered bores database identified a total of eight boreholes or wells within the Survey Area with a number of other sites listed as “unknown” (DoW 2013).

2.4.2 Surfacewater

The Study Area is located in the Murchison River and Salt Lake Basin Surface Water Allocation Areas, within the Murchison River and Salt Lake Basin Surface Water Allocation Sub-areas. This area is not listed under the RIWI Act.

No defined drainage channels or rivers listed under the RIWI Act occur within the Study Area. There are a number of minor drainage channels that intersect the Survey Area including Bubble Creek at the eastern end.

In general, the Meekatharra-Wiluna area experiences low rainfall and ephemeral surface drainage. The topography of the Study Area is typically flat, and forms part of a broad watershed on the interior plateau of Western Australia. The Study Area consists of mostly extensive plains with low hill ranges and plateaux, with the majority of the area having interior drainage into large salt lakes (Mabbutt *et al*. 1963). Central uplands occupy the area to the north of the Study Area, and the inner lowlands contain a central alluvial tract with extensive calcreted valley fills. These lowlands drain mainly eastwards to Lake Way and partly westwards to the Murchison River.

Throughout the Study Area, defined drainage channels in the hilly areas tend to give way rapidly down-valley to alluvial floors and to broader alluvial plains with very restricted channelling (Mabbutt *et al.* 1963). As a result, most of the run-off forms widespread shallow flooding, which is subject to rapid evaporation.

In Meekatharra, about 80% of the rainfall occurs during the winter months between April and September. The remainder falls during summer, and is normally associated with local thunderstorms or southward movement of a tropical cyclone. Meekatharra is at the edge of a major drainage divide, where surface water flows south to the saline Lake Annean and north to the Yalgar River. The surface divide is difficult to distinguish due to the flat topography.

2.4.3 Public drinking water source areas

Meekatharra Water Reserve

A search of the DoW Geographic Data Atlas (DoW 2013) indicated that the western end of the Study Area intersects the Meekatharra Water Reserve, which is a Priority 1 public drinking water source area (Figure 3). The Survey Area does not intersect this water reserve. Meekatharra's water supply is obtained from bores in the Sherwood and Domestic wellfields, where water is abstracted from an unconfined alluvial formation (Water and Rivers Commission 2001).

The main groundwater storage in the Meekatharra area is within the thin deposits of alluvial and colluvial material, which are occasionally underlain by fractured rock aquifers. The wellfields draw groundwater from this unconfined alluvial aquifer. Most rainfall is lost by evaporation or surface runoff and only a small portion infiltrates the soil and recharges the groundwater. The majority of recharge for the Meekatharra source occurs during rainfall events that result in sustained surface flow events.

The water source has the potential to be contaminated by accidental spillages from transport along the Great Northern Highway and fuel storage at bores (Water and Rivers Commission 2001).

In the report for the Meekatharra Water Reserve it is specified that the reserve to the north of the Goldfields highway should be managed for Priority 1 source protection as it represents the sole public drinking water source for the town of Meekatharra (Water and Rivers Commission 2001). The DoW (DoE 2004) indicates that 'major transport infrastructure (roads, railways)' are incompatible in Priority 1 areas. However, the DoW policy is that existing approved land uses / activities can continue at their presently approved leve, provided they operate lawfully.

Wiluna Water Reserve

Wiluna Water Reserve is also located approximately 7.5 km east of the eastern end of the Study Area (Figure 3). The Wiluna wellfield is operated by the Water Corporation and currently consists of two production bores that draw water from a shallow calcrete aquifer. This wellfield draws groundwater from the East Wiluna aquifer that occupies the lower portions of the Negrara and Kukabudda Creek drainage systems (Water Corporation 2004).

No priority classification areas for source protection or protection zones have been assigned to the Wiluna Water Reserve and it is not likely to be impacted by the proposal project.

2.4.4 Wetlands

A search of the EPBC Act PMST database (DotE 2013d) did not identify any Ramsar wetlands within the Study Area. One Nationally Important Wetland, Lake Annean (Lake Nannine) was identified within the Study Area, however it does not intersect the Survey Area. Lake Annean is located approximately 20 km south-west of the Survey Area and has been identified as a good example of a seasonal/intermittent saline/brackish lake and marsh system (DotE 2013b). This lake system is also a regular, major breeding area for Gull-billed Tern (*Gelochelidon nilotica*) and Whiskered Tern (*Chlidonias hybrida*) and provides one of the most important breeding sites for these species in Western Australia.

A search of *WetlandBase* (Western Australian Wetlands Database) (DPaW 2013b) did not identify any wetlands within the Study Area.

670,000 715,000 760,000 805,000

7,080,000

KARALUNDI

Buttah Rd

Mooloogool Rd

Munarra Rd

Great Northern Hwy

Diamond Well-Doolgunna Rd

Patoo Rd

Wiluna North Rd

Goldfields Hwy

MEEKATHARRA

WILUNA

Murchison Downs Rd

Meekatharra-Sandstone Rd

Hillview-Murchison Downs Rd

Young Downs Rd

Narnine-Polelle Rd

Sandstone-Wiluna Rd

Yeelirrie Rd

Meekatharra-Yeelirrie Rd

7,035,000

670,000 715,000 760,000 805,000

1: 450,000 (at A3)

0 5 10 15 20 25

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

LEGEND

- Localities
- Highway
- Minor Road
- Track
- Hydrology
- Impact Area
- Survey Area

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Hydrology

Figure 3

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Data source: Landgate: Virtual Mosaic, Hydrology - 2012, Roads - 20140611; GHD: Study Area, Impact Area - 20140617. Created by: ES

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2.5 Regional biogeography

The Study Area is situated in the Eremaean Botanical Province of Western Australia (Beard 1990), within the Murchison bioregion and the Western and Eastern Murchison sub-regions as described by the Interim Biogeographic Regionalisation of Australia (IBRA) (DotE 2013e). IBRA divides the Australian continent into 89 biogeographic regions based on similar climate, geology, landform, vegetation and fauna (DotE 2013e).

The Western Murchison sub-region comprises Mulga low woodlands that are often rich in ephemerals, on outcrop and fine-textured Quaternary alluvial and eluvial surfaces mantling granitic and greenstone strata of the northern part of the Yilgarn Craton (Desmond *et al*. 2001; McKenzie *et al*. 2002). Throughout this sub-region there are surfaces associated with the occluded drainage, with hummock grasslands occurring on Quaternary sandplains, saltbush shrublands occurring on calcareous soils and *Tecticornia* low shrublands occurring on saline alluvia. This sub-region also contains the headwaters of the Murchison and Wooramel Rivers, which drain westwards to the coast.

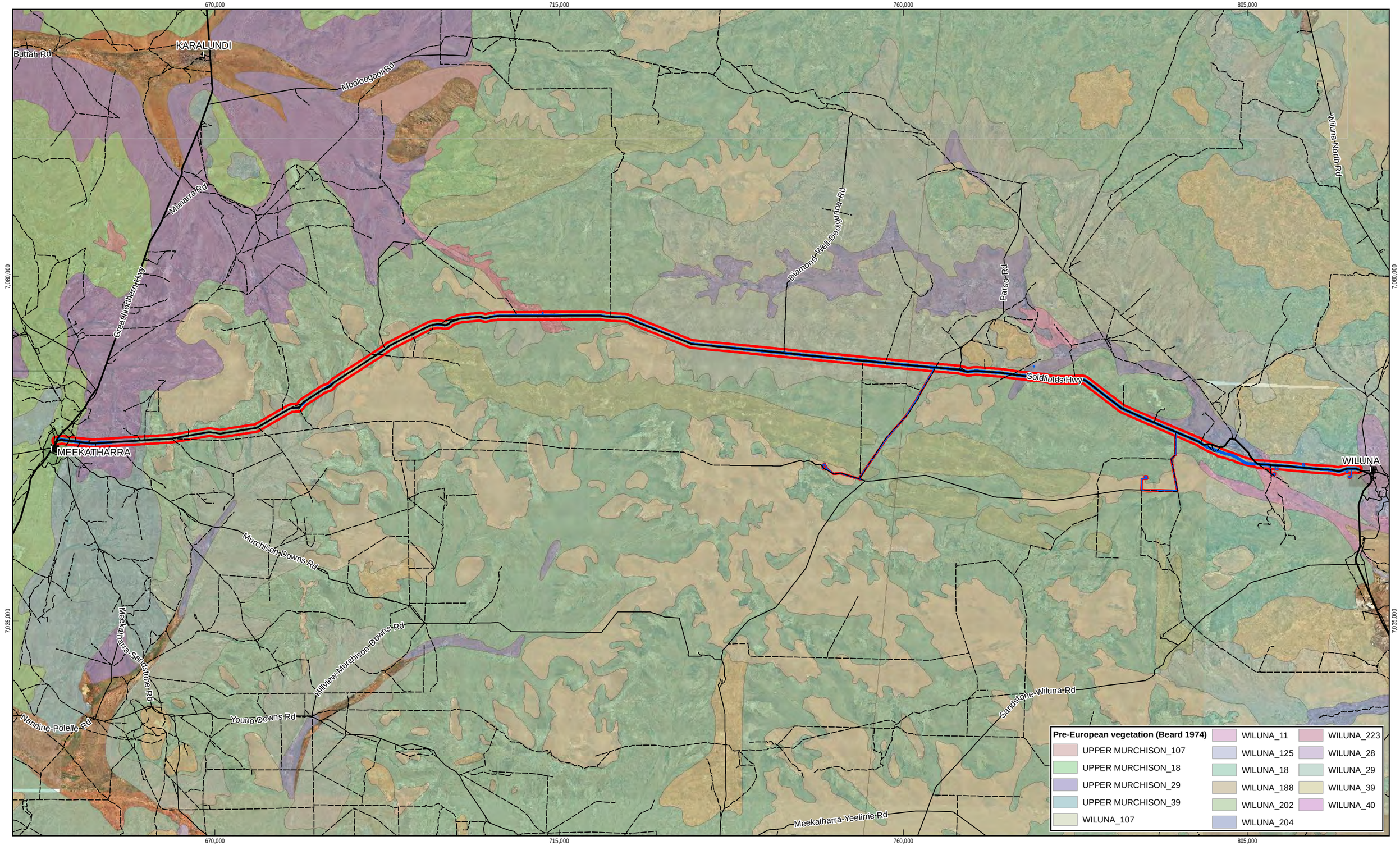
The Eastern Murchison sub-region is characterised by its internal drainage and extensive areas of elevated red desert sandplains with minimal dune development (Cowan 2001; McKenzie *et al*. 2002). Throughout this sub-region there are salt lake systems associated with the occluded Paleodrainage system and broad plains of red-brown soils and breakaway complexes as well as red sandplains. The vegetation is dominated by Mulga woodlands often rich in ephemerals as well as hummock grasslands, saltbush shrublands and *Tecticornia* shrublands.

2.6 Vegetation

2.6.1 Broad vegetation associations

Broad scale (1:1,000,000) vegetation mapping of the Murchison region was completed by Beard (1974) at an association level. Beard (1974) mapping indicates that nine vegetation associations are present within the Survey Area:

- Association 11 – Medium woodland; coolabah
- Association 18 – Low woodland; mulga
- Association 28 – Open low woodland; mulga
- Association 29 – Sparse low woodland; mulga, discontinuous in scattered groups
- Association 39 – Shrublands; mulga scrub
- Association 107 – Hummock grasslands, shrub steppe; mulga and *Eucalyptus kingsmillii* over hard spinifex
- Assocation 202 – Shrublands; mulga & Acacia quadrimarginea scrub
- Association 204 – Succulent steppe with open scrub; scattered mulga & *Acacia sclerosperma* over saltbush & bluebush
- Association 223 – Succulent steppe with open scrub; scattered mulga over saltbush & bluebush



1: 450,000 (at A3)

0 5 10 15 20 25

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

LEGEND

- Localities
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

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Broad-scale Vegetation Associations (Beard 1979)

Figure 4

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Data source: DAFWA: Pre-European Vegetation 20131206; Landgate: Virtual Mosaic, Hydrology - 2012, Roads - 20140611; GHD: Study Area, Impact Area - 20140617. Created by: ES

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2.6.2 Broad vegetation extent and status

Beard mapping has been adapted and digitised by Shepherd *et al.* (2002). The extent of Beard's (1974) vegetation associations have been determined by the state-wide vegetation remaining extent calculations maintained by the DPaW (latest update 2012 -Government of Western Australia 2013c). As shown in Table 6, the extent of vegetation associations 11, 18, 29, 39, 107, 202, 204 and 223 are greater than 98% of the pre-European extent remaining at the state, IBRA bioregion, IBRA sub-region and local government authority (LGA) levels. The extent of vegetation association 28 is greater than 97% of the pre-European extent remaining at the state, IBRA bioregion and IBRA sub-region levels, and there is 66% within the Shire of Wiluna LGA.

Table 6 Vegetation Associations Extent and Status

Vegetation association	Scale	Pre-European Extent (ha)	Current Extent (ha)	Remaining (%)	% Pre-European Extent in IUCN Class I-IV Reserves	% Current Extent in All DEC managed lands
IBRA Region Murchison		28,120,586.77	28,044,823.42	99.73	1.05	7.71
11	State	31,723	31,698	99.92	-	0.00
	Bioregion - Murchison	9,178	9,153	99.73	-	0.00
	Sub-region – Eastern Murchison	8,524	8,499	99.70	-	0.00
	LGA – Shire of Wiluna	7,037	7,012	99.64	-	0.00
18	State	19,892,305	198,437,27	99.76	2.13	6.30
	Bioregion - Murchison	12,403,172	12,363,252	99.68	0.37	4.97
	Sub-region –Western Murchison	2,133,276	2,128,414	99.77	0.00	4.20
	Sub-region – Eastern Murchison	10,269,896	10,234,838	99.96	0.44	5.13
	LGA – Shire of Wiluna	2,039,881	2,030,407	99.54	0.24	3.77
	LGA – Shire of Meekatharra	3,118,037	3,111,401	99.79	2.61	11.11
28	State	395,895	392,172	99.06	-	0.00
	Bioregion - Murchison	224,292	220,584	98.35	-	0.00
	Sub-region – Eastern Murchison	141,411	137,703	97.38	-	0.00
	LGA – Shire of Wiluna	4,523	3,023	66.84	-	0.00
29	State	7,903,991	7,900,200	99.95	0.29	5.23
	Bioregion - Murchison	2,956,382	2,955,695	99.98	-	3.16
	Sub-region – Western Murchison	2,160,147	2,159,669	99.98	-	0.43
	Sub-region – Eastern Murchison	796,235	796,026	99.97	-	10.55
	LGA – Shire of Wiluna	2,027,699	2,027,505	99.99	-	9.99
	LGA – Shire of Meekatharra	2,854,683	2,851,596	99.89	0.03	5.00
39	State	6,613,569	6,602,580	99.83	7.25	12.13
	Bioregion - Murchison	1,148,400	1,138,065	99.10	0.02	3.61
	Sub-region – Western Murchison	437,071	436,130	99.78	-	3.09
	LGA - Shire of Meekatharra	1,367,519	1,365,794	99.87	4.06	6.15
107	State	2,815,387	2,813,996	99.95	1.65	11.55

Vegetation association	Scale	Pre-European Extent (ha)	Current Extent (ha)	Remaining (%)	% Pre-European Extent in IUCN Class I-IV Reserves	% Current Extent in All DEC managed lands
	Bioregion - Murchison	2,792,383	2,790,992	99.95	1.67	11.61
	Sub-region – Eastern Murchison	2,785,303	2,783,912	99.95	1.67	11.58
	LGA – Shire of Meekatharra	287,359	287,359	100	-	44.74
202	State	448,529	448,343	99.96	0.39	21.98
	Bioregion - Murchison	339,742	339,641	99.97	-	21.26
	Sub-region –Western Murchison	61,127	61,115	99.97	-	9.17
	Sub-region – Eastern Murchison	278,615	278,525	99.98	-	23.91
	LGA – Shire of Wiluna	48,553	48,540	99.97	-	0.00
	LGA – Shire of Meekatharra	94,029	94,018	99.99	-	21.95
204	State	199,475	198,735	99.63	7.10	6.78
	Bioregion - Murchison	185,602	184,861	99.60	-	7.28
	Sub-region – Eastern Murchison	75,042	74,306	99.02	-	11.58
	LGA – Shire of Wiluna	39,117	38,380	98.12	-	0.00
223	State	2,597	2,597	100	-	0.00
	Bioregion - Murchison	2,597	2,597	100	-	0.00
	Sub-region – Eastern Murchison	2,597	2,597	100	-	0.00
	LGA – Shire of Meekatharra	2,597	2,597	100	-	0.00

2.6.3 Vegetation associations

During the field assessment six structural formations containing 25 vegetation associations (including two disturbance related associations) were identified within the Survey Area and described based on field observations (Table 7). The vegetation associations have been mapped at Figure 5. The structural formations included:

- Woodlands (containing six vegetation associations)
- Tall shrublands (containing eleven vegetation associations)
- Low shrublands (containing five vegetation associations)
- Tussock grasslands (containing two vegetation associations)
- Hummock grasslands (containing two vegetation associations)
- Disturbed (containing two vegetation associations)

Tall shrublands was the most dominant structural formation throughout the Survey Area, covering approximately 14,769.1 ha. All 11 tall shrubland vegetation associations were dominated by *Acacia* (mostly Mulga group taxa) and *Eremophila* taxa with varying densities of lower stratum shrubs over tussock and/or hummock grasses. These vegetation associations occurred on a wide range of landforms including broadwash and outwash plains, rocky footslopes, and banded ironstone, chert and quartz hills.

Vegetation associations classified as low shrublands were largely restricted to hills, outcrops and breakaways with varying substrates including granite, chert and calcrete (665.4 ha). These associations comprised mixed lower stratum layers dominated by *Eremophila, Ptilotus* and *Calytrix* taxa over tussock grasses. One low shrubland vegetation association, VA14, was dominated by chenopod taxa (including *Sclerolaena, Maireana* and *Tecticornia* spp.) and occurred on low-lying sandy clay areas.

Four grassland associations were described within the Survey Area. The two tussock grassland associations occurred as isolated patches in low lying, clay dominated areas and both included isolated emergent shrubs of *Acacia*, *Grevillea* and *Hakea* spp. The hummock grassland associations were dominated by *Triodia basedowii* and comprised upper and mid-stratum layers dominated by *Acacia* and *Eremophila* taxa. The tussock and hummock grassland associations covered 104.3 ha and 1,155 ha respectively.

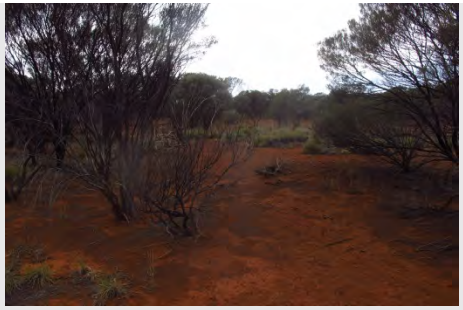
A total of six vegetation associations were classified as woodland associations (955.2 ha), with one association mapped as a mosaic between *Acacia* low woodland and chenopod low shrubland (see VA18). The woodland vegetation associations were dominated by a range of upper stratum taxa including *Eucalyptus, Corymbia, Acacia* and *Santalum*. Two woodland associations were considered to support riparian vegetation, these included VA02 and VA15.

Table 7 Vegetation Associations within the Survey Area

Vegetation association	Description	Landform and/or substrate	Representative sample locations and area (ha)	Notes	Indicative photograph
Structural formation: Woodlands					
VA15 *Eucalyptus* woodland	*Eucalyptus camaldulensis* open woodland over *E. camaldulensis*, *Grevillea striata, Acacia aptaneura* low woodland over *Acacia* spp. tall open shrubland over *Pimelea microcephalus, A. tetragonophylla, Senna artemisioides* subsp. *filifolia* open shrubland over *Aristida contorta, Enneapogon polyphyllus* sparse tussock grassland.	Ephemeral drainage lines and adjacent floodplains	Q33, Q40, Q43, Q107 Extent: 251.2 ha	-	
VA02 *Acacia aptaneura* low woodland	*Acacia aptaneura* with ±*Hakea lorea* low woodland over *A. aptaneura, A. craspedocarpa, A. tetragonophylla* tall open shrubland over *Ptilotus obovatus, Solanum lasiophyllum, Abutilon oxycarpum* low sparse shrubland over *Eriachne helmsii, Eulalia aurea, Aristida contorta* sparse tussock grassland.	Ephemeral drainage lines	Q03, Q16, Q45, T11, T14 Extent: 83 ha	-	
VA03 Mixed *Acacia* low woodland	*Acacia aptaneura, A. pteraneura A. pruinocarpa* low woodland over *A. aptaneura, A. craspedocarpa, A. ramulosa* var. *linophylla, Eremophila fraseri* tall open shrubland over *Acacia* spp. sparse shrubland over *Ptilotus obovatus, Eremophila jucunda*, *Abutilon oxycarpum* low sparse shrubland over *Eriachne helmsii, E. eriopoda, Aristida contorta* sparse tussock grassland.	Floodplains	Q04, Q10, Q20, Q35 Extent: 211.1 ha	-	

Vegetation association	Description	Landform and/or substrate	Representative sample locations and area (ha)	Notes	Indicative photograph
VA05 Mixed low woodland	*Acacia aptaneura, Santalum lanceolatum, A. pteraneura* low woodland over *Sida ectogama, Eremophila latrobei, Senna artemisioides* subsp. *helmsii* sparse shrubland over *Ptilotus obovatus, Abutilon otocarpum* low sparse shrubland over *Aristida contorta, Eragrostis lanipes* isolated clumps of tussock grasses.	Hills, Banded Ironstone and Chert Mt Russell	Q36, Q108 Extent: 8.1 ha	-	
VA24 *Corymbia* open woodland	*Corymbia lenziana, Acacia ayersiana* open woodland over *Grevillea juncifolia* subsp. *juncifolia, A. jamesiana, Pittosporum angustifolium* tall open shrubland over *Alyogyne pinoniana, Acacia sclerosperma* subsp. *sclerosperma, Senna artemisioides* subsp. *filifolia* sparse shrubland over *Dicrastylis sessilifolia, Rhagodia eremaea, Ptilotus polystachyus* low sparse shrubland over *Eriachne helmsii, Eragrostis setifolia, Eriachne helmsii* sparse tussock grassland.	Dunes, sand	Q105 Extent: 4.6 ha	Occurs in only one location, with a very small extent – only one quadrat possible	
VA18 Mosaic of *Acacia* low woodland and Chenopod low shrubland	Mosaic of *Acacia aptaneura, A. pteraneura* low woodland over *A. aptaneura, A. tetragonophylla, A. incurvaneura* tall open shrubland over *Senna artemisioides* subsp. *filifolia, Eremophila glutinosa, E. spectabilis* subsp. *brevis* sparse shrubland, and *Eremophila ?enata, Ptilotus obovatus, Sclerolaena cornishiana, S. cuneata* low sparse shrubland.	Plains, sandy clay, clay	Q38, Q39, T26 Extent: 397.2 ha	-	

Vegetation association	Description	Landform and/or substrate	Representative sample locations and area (ha)	Notes	Indicative photograph
Structural formation: Tall shrublands					
VA01 Mixed tall shrubland on stony plains	*Acacia pteraneura, A. craspedocarpa, A. incurvaneura* tall sparse shrubland over *A. tetragonophylla* isolated shrubs over *Eremophila fraseri, E. forrestii* low sparse shrubland over *Aristida contorta, Eriachne helmsii, Tripogon loliiformis* open tussock grassland.	Stony plains, outwash plains at base of hills	Q02, Q06, Q14, Q103 Extent: 1954.1 ha	-	
VA06 Mixed tall shrubland on stony hills	*Acacia pteraneura* isolated trees *over A. ramulosa* var. *linophylla, A. ?balsamea, Eremophila macmillaniana* tall sparse shrubland over *Senna artemisioioides* subsp. *helmsii, Eremophila macmillaniana, Senna* sp. Meekatharra (E. Bailey 1-26), *Ptilotus obovatus* sparse/low sparse shrubland over *Aristida contorta* open tussock grassland over *Ptilotus helipteroides, P. roei, Goodenia ?triodiophila* isolated clumps of herbs.	Hills, stony	Q09, Q101, T03 Extent: 65 ha	-	

Vegetation association	Description	Landform and/or substrate	Representative sample locations and area (ha)	Notes	Indicative photograph
VA04 Mixed *Acacia* tall shrubland on broadwash plains	*Acacia pteraneura, A. pruinocarpa* isolated trees over *A. caesaneura, A. incurvaneura, A. aptaneura, A. mulganeura* over tall open shrubland over *A. craspedocarpa, A. tetragonophylla, A. ramulosa* var. *linophylla* over *Eremophila flabellata, Ptilotus obovatus, E. forrestii, E. spectabilis* subsp. *brevis* low sparse shrubland over *Eriachne helmsii, Aristida contorta, Eragrostis eriopoda* sparse tussock grassland.	Broadwash plains	Q01, Q05, Q07, Q08, Q11, Q12, Q17, Q19, Q21, Q23, Q27, Q29, Q30, T07, T15, T20, T22, T25 Extent: 10,228.7 ha	Aligns with GHD (2011) TS3	
VA07 Mixed *Acacia* tall shrubland on plains	*Eucalyptus kingsmillii* isolated trees over *Acacia incurvaneura, A. mulganeura, A. pteraneura* tall sparse shrubland over *A. incurvaneura, A. pteraneura, A. ramulosa* var. *linophylla* sparse shrubland over *Eremophila* spp., *Ptilotus obovatus* low sparse shrubland over *Triodia* spp. sparse hummock grassland over *Eriachne helmsii, Eragrostis eriopoda* sparse tussock grassland.	Plains, sandy-loam	Q13, Q34, Q44 Extent: 1,826.8 ha	Aligns with GHD (2011) TS2	
VA08 Mixed *Acacia* tall shrubland on low stony hills	*Acacia pruinocarpa* isolated trees over *A. incurvaneura, A. rhodophloia, A. craspedocarpa* tall open shrubland over *Senna artemisioides* subsp. *helmsii, Eremophila forrestii, E. latrobei* subsp. *latrobei* sparse shrubland over *Sida* sp. Golden calyces, *E. forrestii, E. jucunda* subsp. *jucunda* low sparse shrubland over *Eriachne helmsii, Eragrostis eriopoda* isolated clumps of tussock grasses.	Hills, ironstone and quartz, stony, rocky slopes	Q15, Q104, T10, T13 Extent: 131.1 ha	Aligns with GHD (2011) TS1	

Vegetation association	Description	Landform and/or substrate	Representative sample locations and area (ha)	Notes	Indicative photograph
VA19 Mixed *Acacia* tall shrubland on rocky footslopes	*Acacia pruinocarpa* isolated trees over *Acacia rhodophloia, A. incurvaneura, A. mulganeura* tall open/open shrubland over *Eremophila margarethae, E. forrestii, E. latrobei* subsp. *latrobei, Ptilotus obovatus* low open shrubland over *Triodia melvillei* open hummock grassland over *Eriachne helmsii, Eragrostis eriopoda, E. xerophila* isolated clumps of tussock grasses	Hills, footslopes of rocky hills, dissected by many drainage channels	Q41, Q42, T27 Extent: 351 ha	-	
VA22 Mixed *Acacia* tall shrubland on BIF	*Acacia incurvaneura, A. ayersiana* (narrow phyllodes variant) tall shrubland over *Eremophila fraseri, Senna artemisioides* subsp. *helmsii*, *S*. sp. Meekatharra (E. Bailey) sparse shrubland over *Eremophila exilifolia, Ptilotus obovatus, Tribulus suberosus* low sparse shrubland over *Aristida contorta* open tussock grassland over *Ptilotus helipteroides, Cheilanthes sieberi*, *Lepidium oxytrichum* sparse herbland.	Hills, banded ironstone	Q100 Extent: 31.5 ha	-	
VA09 *Acacia burkittii* tall shrubland	*Acacia burkittii* tall open shrubland over *A. burkittii, A. tetragonophylla, Grevillea striata* sparse shrubland over *Senna artemisioides* subsp. *filiformis*, *Ptilotus obovatus, Salsola australis* low open shrubland over *Aristida contorta* isolated clumps of tussock grasses.	Hills, low, quartz, ironstone pebbles	Q18, Q47, T16 Extent: 120.4 ha	-	

Vegetation association	Description	Landform and/or substrate	Representative sample locations and area (ha)	Notes	Indicative photograph
VA25 *Acacia rhodophloia* tall shrubland	*Acacia rhodophloia A. incurvaneura,* tall shrubland over *Eremophila congesta* (P1), *E. latrobei* subsp*. latrobei, E. punctata* open shrubland over *E. jucunda* subsp*. jucunda, E. latrobei* subsp*. latrobei, E. congesta* (P1), *Sida* sp. Golden calyces low open shrubland over *Eriachne helmsii, Eragrostis eriopoda* isolated clumps of tussock grasses*.*	Hills, chert	Q109 Extent: 51.5 ha	-	
VA26 *Casuarina pauper* tall shrubland	*Casuarina pauper* tall shrubland with *Hakea preissii, Grevillea striata, Acacia tetragonophylla, A. aptaneura, A. incurvaneura* isolated tall shrubs/shrubs over *Sclerolaena cuneata, Maireana. triptera, Ptilotus obovatus* low open shrubland.	Plains – calcareous / sodic soils	Extent: 3 ha		
VA27 Mixed *Acacia* tall shrubland on plains	*Eucalyptus lucasii* and *E. eremicola* subsp. *peeneri* isolated mallees over *Acacia murrayana* tall sparse shrubland with *A. incurvaneura, A. pteraneura, A. ramulosa* var*. linophylla* sparse shrubland over *Eremophila* spp., *Ptilotus obovatus* low sparse shrubland over *Triodia* spp. sparse hummock grassland over *Eriachne helmsii, Eragrostis eriopoda* sparse tussock grassland.	Plains, loamy sands	Extent: 6 ha		

Vegetation association	Description	Landform and/or substrate	Representative sample locations and area (ha)	Notes	Indicative photograph
Structural formation: Low shrublands					
VA12 *Eremophila* low shrubland	*Acacia pruinocarpa*, *A. incurvaneura* isolated trees over *A. rhodophloia, Senna artemisioides* subsp. x *sturtii, S. glutinosa subsp. x luerssenii* sparse shrubland over *Eremophila latrobei, E. jucunda* subsp. *jucunda, Ptilotus obovatus, Senna artemisioides* subsp. *petiolaris* low open shrubland over *Eriachne helmsii, E. mucronata, Neurachne minor* sparse tussock grassland over *Ptilotus schwartzii* isolated clumps of herbs.	Hills, low, rocky	Q28 Extent: 30 ha	-	
VA21 Mixed low shrubland on granite outcrops	*Acacia aptaneura* isolated trees over *A. quadrimarginea, A. incurvaneura, A. ramulosa* var. *linophylla* tall sparse shrubland over *Eremophila exilifolia*, *E. fraseri* open shrubland over *Ptilotus obovatus, E. jucunda* subsp. *jucunda*, *E. forrestii* low open shrubland over *Aristida contorta, Eriachne helmsii* sparse tussock grassland.	Hills, granite, granite outcrops, quartz	Q48 Extent: 19 ha	-	
VA23 Mixed low shrubland on outcrops	*Acacia quadrimarginea* sparse shrubland over *Calytrix carinata, C. desolata, Prostanthera campbellii, Micromyrtus sulphurea* low shrubland over *Eriachne mucronata* tussock grassland over *Stylidium longibracteatum* isolated clumps of herbs.	Outcrops, chert	T09, T12, GHD (2013) SLK740 transect Extent: 35.5 ha	Aligns with GHD (2013) VT12 Outcrop	

Vegetation association	Description	Landform and/or substrate	Representative sample locations and area (ha)	Notes	Indicative photograph
VA20 Mixed low shrubland on calcareous breakaways	*Acacia pteraneura, A. incurvaneura* tall sparse shrubland over *A. quadrimarginea, A. tetragonophylla, Eremophila latrobei* subsp. *latrobei* open shrubland over *Dodonaea pachyneura, Ptilotus obovatus, Eremophila latrobei* subsp. *latrobei* low open shrubland over *Aristida contorta, Eriachne pulchella* subsp. *dominii, E. mucronata* sparse tussock grassland.	Breakaways, calcareous	Q49, Q102, T04, T05, T08, T21 Extent: 148.4ha	-	
VA14 Chenopod low shrubland	*Hakea preissii, Grevillea striata, Acacia tetragonophylla, A. aptaneura, A. incurvaneura* isolated tall shrubs/shrubs over *Sclerolaena cuneata, Maireana. triptera, Ptilotus obovatus* low open shrubland.	Plains, sandy-clay	Q32, Q37, Q46, T24 Extent: 432.5 ha	-	
Structural formation: Tussock grasslands					
VA10 Open tussock grassland	*Grevillea berryana, Acacia incurvaneura* isolated shrubs over *Eremophila forrestii*, *Eremophila margarethae* low isolated shrubs over *Eriachne mucronata, Eragrostis xerophila* open tussock grassland over *Ptilotus schwartzii* isolated herbs.	Plains, loamy sand	Q22 Extent: 55 ha	Aligns with GHD (2013) VT8 Open Tussock Grassland	

Vegetation association	Description	Landform and/or substrate	Representative sample locations and area (ha)	Notes	Indicative photograph
VA13 *Eriachne* tussock grassland	*Hakea lorea, Acacia aptaneura* isolated trees over *Hakea preissii, A. tetragonophylla* isolated shrubs over *Eriachne benthamii* tussock grassland.	Drainage depression, freshwater claypans	Q31, Q106 Extent: 49.3 ha	-	
Structural formation: Hummock grassland					
VA11 *Triodia* hummock grassland	*Acacia pteraneura* isolated trees over *A. incurvaneura, A. caesaneura, A. mulganeura* tall shrubland over *A. ramulosa var. linophylla* isolated shrubs over *Eremophila forrestii, Ptilotus obovatus, Psydrax suaveolens* low isolated shrubs over *Triodia basedowii* hummock grassland.	Plains, sandy-clay-loam	Q24, Q25, Q26, T18, T19 Extent: 1139.5 ha	-	
VA28 *Triodia basedowii* hummock grassland	*Corymbia lenziana* isolated trees over *Acacia ramulsoa* var *ramulosa* isolated shrubs over *Keraudrenia* sp. over *Triodia basedowii* hummock grassland.	Plains; sandy-loam	Extent: 15.5 ha		

Vegetation association	Description	Landform and/or substrate	Representative sample locations and area (ha)	Notes	Indicative photograph
Disturbed					
16	Previously cleared areas with regrowth present. This includes borrow pits at various stages of regrowth.		Extent: 178.4 ha	-	
17	Cleared/highly disturbed. This includes, roads, tracks, infrastructure and permanently cleared areas		Extent: 135 ha	-	

650,000 655,000 660,000 665,000

7,060,000

7,055,000

Great Northern Hwy

Goldfields Hwy

Meekatharra-Sandstone Rd

Campbell Rd

Meeleary St

Main St

High St

Hill St

Darlot St

Railway St

Q03 Q04 Q05 Q06 Q07 Q102 Q49

T04 T05 T06 T07

775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793

1 2 3 4 16 17 20

Vegetation Type

- VA01: Mixed *Acacia* and *Eremophila* tall shrubland on stony outwash plains
- VA02: *Acacia aptaneura* low woodland on ephemeral drainage lines
- VA03: Mixed *Acacia* low woodland over tussock grassland on floodplains
- VA04: Mixed *Acacia* tall shrubland over tussock grassland on broadwash plains
- VA05: Mixed low woodland on banded ironstone and chert hills
- VA06: Mixed tall shrubland on stony hills
- VA07: Mixed *Acacia* tall shrubland over hummock and tussock grassland on plains
- VA08: Mixed *Acacia* tall shrubland on low stony hills
- VA09: *Acacia burkittii* tall shrubland on quartz and ironstone hills
- VA10: Open tussock grassland on loamy-sand plains
- VA11: *Triodia* hummock grassland on sandy clay-loam plains
- VA12: *Eremophila* low shrubland on low rocky hills
- VA13: *Eriachne* tussock grassland on drainage depressions/freshwater claypans
- VA14: Chenopod low shrubland on sandy-clay plains
- VA15: *Eucalyptus camaldulensis* woodland over mixed shrubland in ephemeral drainage lines and adjacent floodplains
- 16: Previously cleared/regrowth. Includes borrow pits at various stages of regrowth
- 17: Cleared/highly disturbed
- VA18: Mosaic of *Acacia* low woodland and Chenopod low shrubland on sandy clay plains
- VA19: Mixed *Acacia* tall shrubland on rocky footslopes
- VA20: Mixed low shrubland on calcareous breakaways
- VA21: Mixed *Acacia* and *Eremophila* low shrubland on granite and quartz outcrops
- VA22: Mixed *Acacia* tall shrubland on banded ironstone hills
- VA23: Mixed low shrubland on outcrops
- VA24: *Corymbia lenziana* open woodland on sand dunes
- VA25: *Acacia rhodophloia* tall shrubland on chert hills
- VA26: *Casuarina pauper* tall shrubland on plains: calcareous soils
- VA27: *Acacia murrayana* tall shrubland on plains
- VA28: *Triodia basedowii* hummock grassland on sandy-loam plains

650,000 655,000 660,000 665,000

1:50,000 (at A3)

0 0.5 1 1.5 2 2.5

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Quadrat
- Transect
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map

1 MEEKATHARRA 2 3 4 5 6 7 8 9 WILUNA 10 11

Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Job Number 61-30097
Revision 0
Date 17 Sep 2014

Vegetation type and survey locations

Sheet 1 of 11

Figure 5

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Data source: GA: Topo 250k Series 3 - 2006; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; GHD: Vegetation Type - 20131119. Created by: bflorczak

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670,000 675,000 680,000 685,000

7,065,000

7,060,000

Goldfields Hwy

Q01 Q02 Q08 Q09 Q10 Q11 Q100 Q101 T01 T02 T03

753 754 755 756 757 758 759 760 762 763 765 766 768 769 770 771 772 773 774

1 3 4 6 7 16 17 20 22

Vegetation Type

- VA01: Mixed *Acacia* and *Eremophila* tall shrubland on stony outwash plains
- VA02: *Acacia aptaneura* low woodland on ephemeral drainage lines
- VA03: Mixed *Acacia* low woodland over tussock grassland on floodplains
- VA04: Mixed *Acacia* tall shrubland over tussock grassland on broadwash plains
- VA05: Mixed low woodland on banded ironstone and chert hills
- VA06: Mixed tall shrubland on stony hills
- VA07: Mixed *Acacia* tall shrubland over hummock and tussock grassland on plains
- VA08: Mixed *Acacia* tall shrubland on low stony hills
- VA09: *Acacia burkittii* tall shrubland on quartz and ironstone hills
- VA10: Open tussock grassland on loamy-sand plains
- VA11: *Triodia* hummock grassland on sandy clay-loam plains
- VA12: *Eremophila* low shrubland on low rocky hills
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- VA27: *Acacia murrayana* tall shrubland on plains
- VA28: *Triodia basedowii* hummock grassland on sandy-loam plains

1:50,000 (at A3)

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Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Quadrat
- Transect
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map

1 MEEKATHARRA 2 3 4 5 6 7 8 9 WILUNA 10 11

Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Job Number 61-30097
Revision 0
Date 17 Sep 2014

Vegetation type and survey locations

Sheet 2 of 11

Figure 5

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Data source: GA: Topo 250k Series 3 - 2006; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; GHD: Vegetation Type - 20131119. Created by: bflorczak

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690,000 695,000 700,000 705,000

7,075,000 7,070,000

Goldfields Hwy

Q103 Q104 Q105 Q12 Q13 Q14 Q15 Q16 Q48

T08 T09 T10 T11 T12 T13 T14

731 732 734 735 736 737 739 740 741 742 744 745 746 747 748 749 750 751 752

2 4 7 8 16 20 21 23 24

Vegetation Type

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1:50,000 (at A3)

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Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Quadrat
- Transect
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map

1 MEEKATHARRA 2 3 4 5 6 7 8 9 WILUNA 10 11

Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Vegetation type and survey locations

Job Number	61-30097
Revision	0
Date	17 Sep 2014

Sheet 3 of 11

Figure 5

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Data source: GA: Topo 250k Series 3 - 2006; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; GHD: Vegetation Type - 20131119. Created by: bflorczak

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710,000 715,000 720,000 725,000

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730 Q17 729 T15 728 727 726 725 724 723 722 721 720 719 718 Q20 716 715 714 712 711

16 4 9 Q18 4 3 T16 Q47 9 Goldfields Hwy T17 Q19 22 13 4 3 17 13 16 10 Q21 16

Vegetation Type

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1:50,000 (at A3)

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Kilometres

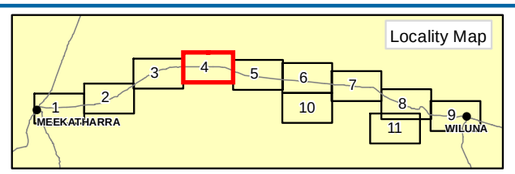
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Quadrat
- Transect
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map



Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Vegetation type and survey locations

Job Number	61-30097
Revision	0
Date	17 Sep 2014

Sheet 4 of 11

Figure 5

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Data source: GA: Topo 250k Series 3 - 2006; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; GHD: Vegetation Type - 20131119. Created by: bflorczak

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730,000 735,000 740,000 745,000

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Goldfields Hwy

Diamond Well-Doolgunna Rd

710 709 Q22 10 708 16 707 4 10 706 705 Q23 703 701 Q24 700 T19 699 11 T18 697 696 Q25 16 695 694 693 4 Q26 11 692 691

Vegetation Type

- VA01: Mixed *Acacia* and *Eremophila* tall shrubland on stony outwash plains
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1:50,000 (at A3)

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Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Quadrat
- Transect
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map

1 MEEKATHARRA 2 3 4 5 6 7 8 9 WILUNA 10 11

Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Job Number 61-30097
Revision 0
Date 17 Sep 2014

Vegetation type and survey locations

Figure 5

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Data source: GA: Topo 250k Series 3 - 2006; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; GHD: Vegetation Type - 20131119. Created by: bflorczak

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750,000 755,000 760,000 765,000

7,075,000 7,070,000 7,065,000

Vegetation Type

- VA01: Mixed *Acacia* and *Eremophila* tall shrubland on stony outwash plains
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690 689 688 687 686 685 684 683 682 681 679 678 677 676 675 674 672 671

16 14 10 16 20 4 12 16 12 20 7 11 8

T20 T21 T22 Q27 Q28 Q29 Q30

Goldfields Hwy

MEEKATHARRA WILUNA

1:50,000 (at A3)

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Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Quadrat
- Transect
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map

1 2 3 4 5 6 7 8 9 10 11

MEEKATHARRA WILUNA

Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Job Number	61-30097
Revision	0
Date	17 Sep 2014

Vegetation type and survey locations

Sheet 6 of 11

Figure 5

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Data source: GA: Topo 250k Series 3 - 2006; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; GHD: Vegetation Type - 20131119. Created by: bflorczak

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7,065,000

Parroo Rd

Goldfields Hwy

670 668 667 666 665 664 663 662 661 659 658 657 656 654 653 652 651 650

Q106 Q31 Q32 T23 Q107 T24 Q33 Q34 T25 Q36 Q108 Q35

7 11 13 16 4 1 15 14 7 16 5 3

Vegetation Type

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1:50,000 (at A3)

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Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Quadrat
- Transect
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map

1 MEEKATHARRA 2 3 4 5 6 7 8 9 WILUNA 10 11

GHD | mainroads WESTERN AUSTRALIA | powered by SLIP ENABLER

Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Job Number	61-30097
Revision	0
Date	17 Sep 2014

Vegetation type and survey locations

Sheet 7 of 11

Figure 5

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Data source: GA: Topo 250k Series 3 - 2006; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; GHD: Vegetation Type - 20131119. Created by: bflorczak

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7,065,000 7,060,000 7,055,000

Vegetation Type

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649 4 Q37 648 14 18 646 4 14 Q46 18 Q38 643 642 641 18 640 T26 Q39 14 639 13 638 637 4 636 635 Goldfields Hwy 15 633 632 631 630 629 628 627 15 25 7 19 26 4 27 26 27 7 27

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Kilometres

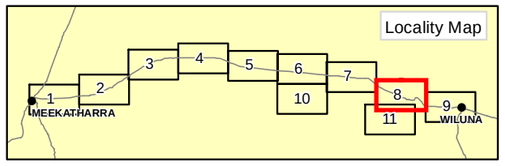
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Quadrat
- Transect
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map



Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Job Number	61-30097
Revision	0
Date	17 Sep 2014

Vegetation type and survey locations

Sheet 8 of 11

Figure 5

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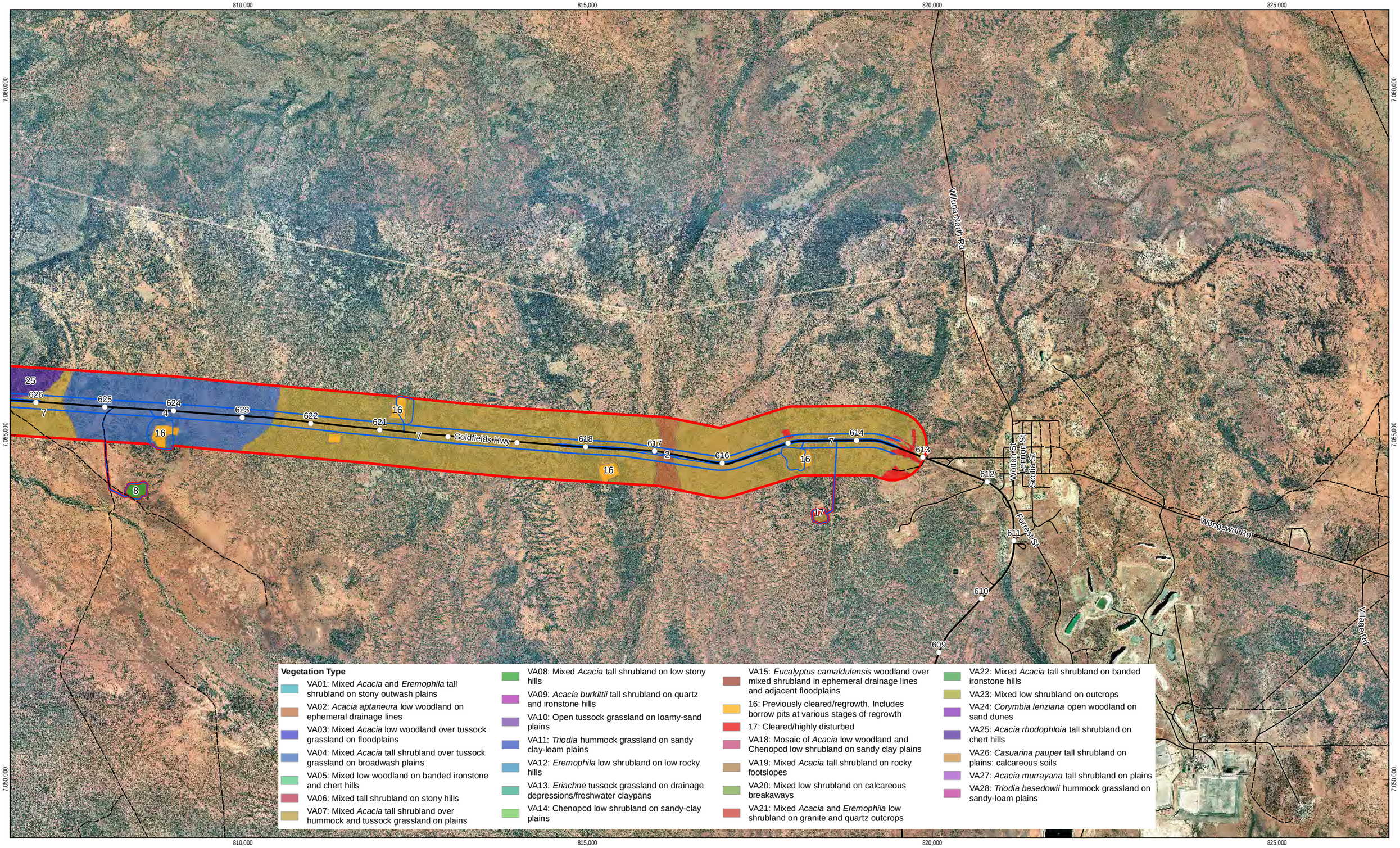
Data source: GA: Topo 250k Series 3 - 2006; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; GHD: Vegetation Type - 20131119. Created by: bflorczak



Vegetation Type

- VA01: Mixed *Acacia* and *Eremophila* tall shrubland on stony outwash plains
- VA02: *Acacia aptaneura* low woodland on ephemeral drainage lines
- VA03: Mixed *Acacia* low woodland over tussock grassland on floodplains
- VA04: Mixed *Acacia* tall shrubland over tussock grassland on broadwash plains
- VA05: Mixed low woodland on banded ironstone and chert hills
- VA06: Mixed tall shrubland on stony hills
- VA07: Mixed *Acacia* tall shrubland over hummock and tussock grassland on plains
- VA08: Mixed *Acacia* tall shrubland on low stony hills
- VA09: *Acacia burkittii* tall shrubland on quartz and ironstone hills
- VA10: Open tussock grassland on loamy-sand plains
- VA11: *Triodia* hummock grassland on sandy clay-loam plains
- VA12: *Eremophila* low shrubland on low rocky hills
- VA13: *Eriachne* tussock grassland on drainage depressions/freshwater claypans
- VA14: Chenopod low shrubland on sandy-clay plains
- VA15: *Eucalyptus camaldulensis* woodland over mixed shrubland in ephemeral drainage lines and adjacent floodplains
- 16: Previously cleared/regrowth. Includes borrow pits at various stages of regrowth
- 17: Cleared/highly disturbed
- VA18: Mosaic of *Acacia* low woodland and Chenopod low shrubland on sandy clay plains
- VA19: Mixed *Acacia* tall shrubland on rocky footslopes
- VA20: Mixed low shrubland on calcareous breakaways
- VA21: Mixed *Acacia* and *Eremophila* low shrubland on granite and quartz outcrops
- VA22: Mixed *Acacia* tall shrubland on banded ironstone hills
- VA23: Mixed low shrubland on outcrops
- VA24: *Corymbia lenziana* open woodland on sand dunes
- VA25: *Acacia rhodophloia* tall shrubland on chert hills
- VA26: *Casuarina pauper* tall shrubland on plains: calcareous soils
- VA27: *Acacia murrayana* tall shrubland on plains
- VA28: *Triodia basedowii* hummock grassland on sandy-loam plains

1:50,000 (at A3)

0 0.5 1 1.5 2 2.5

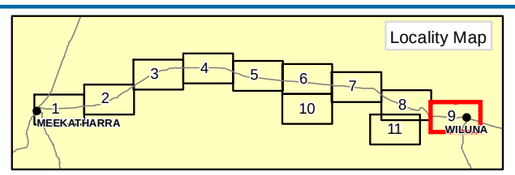
Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Quadrat
- Transect
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area



Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Job Number	61-30097
Revision	0
Date	17 Sep 2014

Vegetation type and survey locations

Sheet 9 of 11

Figure 5

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Data source: GA: Topo 250k Series 3 - 2006; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; GHD: Vegetation Type - 20131119. Created by: bflorczak

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750,000 755,000 760,000 765,000

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Vegetation Type

- VA01: Mixed *Acacia* and *Eremophila* tall shrubland on stony outwash plains
- VA02: *Acacia aptaneura* low woodland on ephemeral drainage lines
- VA03: Mixed *Acacia* low woodland over tussock grassland on floodplains
- VA04: Mixed *Acacia* tall shrubland over tussock grassland on broadwash plains
- VA05: Mixed low woodland on banded ironstone and chert hills
- VA06: Mixed tall shrubland on stony hills
- VA07: Mixed *Acacia* tall shrubland over hummock and tussock grassland on plains
- VA08: Mixed *Acacia* tall shrubland on low stony hills
- VA09: *Acacia burkittii* tall shrubland on quartz and ironstone hills
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- VA12: *Eremophila* low shrubland on low rocky hills
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- VA23: Mixed low shrubland on outcrops
- VA24: *Corymbia lenziana* open woodland on sand dunes
- VA25: *Acacia rhodophloia* tall shrubland on chert hills
- VA26: *Casuarina pauper* tall shrubland on plains: calcareous soils
- VA27: *Acacia murrayana* tall shrubland on plains
- VA28: *Triodia basedowii* hummock grassland on sandy-loam plains

8 7 4 8 7 16 28 14 12 28 8

1:50,000 (at A3)

0 0.5 1 1.5 2 2.5

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Quadrat
- Transect
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map

1 MEEKATHARRA 2 3 4 5 6 7 8 9 WILUNA 10 11

Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Vegetation type and survey locations

Job Number	61-30097
Revision	0
Date	17 Sep 2014

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Figure 5

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Data source: GA: Topo 250k Series 3 - 2006; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; GHD: Vegetation Type - 20131119. Created by: bflorczak

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785,000 790,000 795,000 800,000

7,055,000

7,050,000

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7 27 26

Vegetation Type

- VA01: Mixed *Acacia* and *Eremophila* tall shrubland on stony outwash plains
- VA02: *Acacia aptaneura* low woodland on ephemeral drainage lines
- VA03: Mixed *Acacia* low woodland over tussock grassland on floodplains
- VA04: Mixed *Acacia* tall shrubland over tussock grassland on broadwash plains
- VA05: Mixed low woodland on banded ironstone and chert hills
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- VA07: Mixed *Acacia* tall shrubland over hummock and tussock grassland on plains
- VA08: Mixed *Acacia* tall shrubland on low stony hills
- VA09: *Acacia burkittii* tall shrubland on quartz and ironstone hills
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- VA21: Mixed *Acacia* and *Eremophila* low shrubland on granite and quartz outcrops
- VA22: Mixed *Acacia* tall shrubland on banded ironstone hills
- VA23: Mixed low shrubland on outcrops
- VA24: *Corymbia lenziana* open woodland on sand dunes
- VA25: *Acacia rhodophloia* tall shrubland on chert hills
- VA26: *Casuarina pauper* tall shrubland on plains: calcareous soils
- VA27: *Acacia murrayana* tall shrubland on plains
- VA28: *Triodia basedowii* hummock grassland on sandy-loam plains

785,000 790,000 795,000 800,000

1:50,000 (at A3)

0 0.5 1 1.5 2 2.5

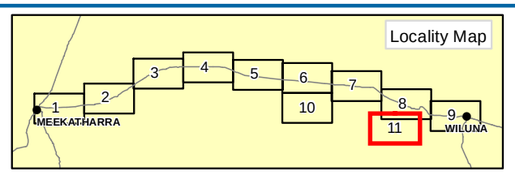
Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Quadrat
- Transect
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area



Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Vegetation type and survey locations

Job Number	61-30097
Revision	0
Date	17 Sep 2014

Sheet 11 of 11

Figure 5

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Data source: GA: Topo 250k Series 3 - 2006; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; GHD: Vegetation Type - 20131119. Created by: bflorczak

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2.6.4 Vegetation condition

The vegetation condition of the Survey Area ranged from *Excellent* (2) to *Completely Degraded* (6) (Vegetation condition rating scale – Keighery 1994). The majority of the Survey Area was rated as *Excellent* (2) to *Very Good* (3) or *Very Good* (3), with areas in the vicinity of Meekatharra and Wiluna having lower condition ratings due to increased anthropogenic disturbances observed. Areas of better vegetation condition were generally recorded from breakaways, outcrops and stony hills.

Grazing by livestock, native mammals and feral animals has altered vegetation composition across the Survey Area, with palatable taxa being far more heavily grazed. Grazing and trampling impacts were generally more prevalent within drainage lines and adjacent floodplain areas, as well as the margins of artificial water sources.

The most noticeable areas of disturbance throughout the Survey Area included existing borrow pits, pastoral infrastructure (e.g. dams, access tracks, holding yards) and roadside margins. Permanently cleared areas, such as roads and tracks were rated as *Completely Degraded* (6), whilst previously cleared, but regenerating borrow pits were rated as *Good* (4) to *Degraded* (5).

The diversity and density of introduced flora taxa (weeds) was considered relatively low throughout the Survey Area, given the proximity to the Goldfields Highway and the dominant land use (pastoralism) across the site.

The soil profile with the Survey Area was considered dry at the time of survey, however, recent rain was evident in the Meekatharra area with moderate to high numbers of annual taxa recorded. The number of annual taxa recorded decreased significantly east of Meekatharra and signs of plant water stress also became more apparent.

The time since fire throughout the Survey Area was determined to be long (>5 years) with no recently burnt areas observed. Whilst several burns scars were observed, these areas were small and likely burnt longer than five years ago.

The extents of the vegetation condition ratings mapped within the Survey Area are detailed in Table 8.

Table 8 Extents of vegetation condition ratings mapped within the Survey Area

Vegetation Condition	Extent (ha)
Condition 1 (Pristine or nearly so)	4.61
Condition 1-2	1.15
Condition 2 (Excellent)	1280.86
Condition 2-3	9609.42
Condition 3 (Very Good)	5329.09
Condition 3-4	892.47
Condition 4 (Good)	535.54
Condition 4-5	102.12
Condition 5 (Degraded)	3.41
Condition 5-6	54.26
Condition 6 (Completely Degraded)	149.3

650,000 655,000 660,000 665,000

7,060,000

7,055,000

Great Northern Hwy

Goldfields Hwy

Main St

High St

Hill St

Daldorf St

Railway St

Campbell Rd

Mecleary St

Meekatharra-Sandstone Rd

Murchison Downs Rd

792 793 791 790 789 788 787 786 785 784 783 782 781 780 779 778 777 776 775

4-5 4 6 5-6 4 6 3-4 3-4 2-3 2 2-3

Vegetation Condition

- 1. Pristine or Nearly so
- 1-2
- 2. Excellent
- 2-3
- 3. Very Good
- 3-4
- 4. Good
- 4-5
- 5. Degraded
- 5-6
- 6. Completely Degraded

650,000 655,000 660,000 665,000

1:50,000 (at A3)

0 0.5 1 1.5 2 2.5

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map

1 MEEKATHARRA 2 3 4 5 6 7 8 9 WILUNA 10 11

Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Job Number 61-30097
Revision 0
Date 17 Sep 2014

Sheet 1 of 11

Vegetation Condition

Figure 6

G:\61\30097\GIS\Maps\MXD\6130097_G002_Fig6_Rev0.mxd

Data source: GA: Mainlands, Roads, Localities - 2007; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; MRWA: SLK - 20131219; GHD: Vegetation Condition - 20140617, Study Area, Impact Area - 20140617. Created by: bflorczak

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670,000 675,000 680,000 685,000

7,065,000

7,060,000

2-3 753 754 755 756 2-3 757 758 759 760 4-5 2 761 762 2-3 763 Goldfields Hwy 765 2-3 766 767 768 2-3 769 770 771 2-3 6 772 773 774 2-3

Vegetation Condition

- 1. Pristine or Nearly so
- 1-2
- 2. Excellent
- 2-3
- 3. Very Good
- 3-4
- 4. Good
- 4-5
- 5. Degraded
- 5-6
- 6. Completely Degraded

1:50,000 (at A3)

0 0.5 1 1.5 2 2.5

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map

1 MEEKATHARRA 2 3 4 5 6 7 8 9 WILUNA 10 11

Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Job Number	61-30097
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Date	17 Sep 2014

Figure 6

Vegetation Condition

G:\61\30097\GIS\Maps\MXD\6130097_G002_Fig6_Rev0.mxd

Data source: GA: Mainlands, Roads, Localities - 2007; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; MRWA: SLK - 20131219; GHD: Vegetation Condition - 20140617, Study Area, Impact Area - 20140617. Created by: bflorczak

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690,000 695,000 700,000 705,000

7,075,000

7,070,000

Goldfields Hwy

731 732 734 735 736 737 738 739 740 741 742 744 745 746 747 748 749 750 751 752

1 2 3 4-5 2-3

Vegetation Condition

1. Pristine or Nearly so	3-4
1-2	4. Good
2. Excellent	4-5
2-3	5. Degraded
3. Very Good	5-6
	6. Completely Degraded

690,000 695,000 700,000 705,000

1:50,000 (at A3)

0 0.5 1 1.5 2 2.5

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map

1 MEEKATHARRA 2 3 4 5 6 7 8 9 WILUNA 10 11

Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Job Number	61-30097
Revision	0
Date	17 Sep 2014

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Vegetation Condition

Figure 6

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Data source: GA: Mainlands, Roads, Localities - 2007; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; MRWA: SLK - 20131219; GHD: Vegetation Condition - 20140617, Study Area, Impact Area - 20140617. Created by: bflorczak

710,000 715,000 720,000 725,000

7,080,000 7,075,000 7,070,000

730 729 728 727 726 725 724 723 722 721 720 719 718 717 716 715 714 713 712 711

Goldfields Hwy

3 4-5 3 3-4 3 2 4 3 6 3 4-5

MEEKATHARRA WILUNA

1 2 3 4 5 6 7 8 9 10 11

Vegetation Condition

- 1. Pristine or Nearly so
- 1-2
- 2. Excellent
- 2-3
- 3. Very Good
- 3-4
- 4. Good
- 4-5
- 5. Degraded
- 5-6
- 6. Completely Degraded

1:50,000 (at A3)

0 0.5 1 1.5 2 2.5

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map

Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Job Number	61-30097
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Figure 6

Vegetation Condition

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Data source: GA: Mainlands, Roads, Localities - 2007; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; MRWA: SLK - 20131219; GHD: Vegetation Condition - 20140617, Study Area, Impact Area - 20140617. Created by: bflorczak

730,000 735,000 740,000 745,000

7,075,000

7,070,000

Diamond Well-Doolgunna Rd

Goldfields Hwy

710 709 708 707 706 705 704 703 701 700 699 698 697 696 695 694 693 692 691

3 4-5 3 2 2-3 2

Vegetation Condition

- 1. Pristine or Nearly so
- 1-2
- 2. Excellent
- 2-3
- 3. Very Good
- 3-4
- 4. Good
- 4-5
- 5. Degraded
- 5-6
- 6. Completely Degraded

730,000 735,000 740,000 745,000

1:50,000 (at A3)

0 0.5 1 1.5 2 2.5

Kilometres

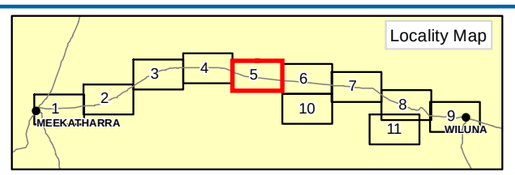
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map



Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Job Number	61-30097
Revision	0
Date	17 Sep 2014

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Figure 6

Vegetation Condition

Data source: GA: Mainlands, Roads, Localities - 2007; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; MRWA: SLK - 20131219; GHD: Vegetation Condition - 20140617, Study Area, Impact Area - 20140617. Created by: bflorczak

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750,000 755,000 760,000 765,000

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690 689 688 687 686 685 684 683 682 681 679 678 677 676 675 674 673 672 671

Goldfields Hwy

5 2 2-3 4-5 2 2-3 4-5 2 2-3

Vegetation Condition

1. Pristine or Nearly so	3-4
1-2	4. Good
2. Excellent	4-5
2-3	5. Degraded
3. Very Good	5-6
	6. Completely Degraded

1:50,000 (at A3)

0 0.5 1 1.5 2 2.5

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map

1 MEEKATHARRA 2 3 4 5 6 7 8 9 WILUNA 10 11

Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Job Number	61-30097
Revision	0
Date	17 Sep 2014

Figure 6

Vegetation Condition

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Data source: GA: Mainlands, Roads, Localities - 2007; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; MRWA: SLK - 20131219; GHD: Vegetation Condition - 20140617, Study Area, Impact Area - 20140617. Created by: bflorczak

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770,000 775,000 780,000 785,000

7,070,000

7,065,000

Paroo Rd

Goldfields Hwy

670 669 668 667 666 665 664 663 662 661 659 658 657 656 654 653 652 651 650

2-3 4-5 3 3-4 2-3 2 3

Vegetation Condition

1. Pristine or Nearly so	3-4
1-2	4. Good
2. Excellent	4-5
2-3	5. Degraded
3. Very Good	5-6
	6. Completely Degraded

1:50,000 (at A3)

0 0.5 1 1.5 2 2.5

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map

1 MEEKATHARRA 2 3 4 5 6 7 8 9 WILUNA 10 11

Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Job Number	61-30097
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Date	17 Sep 2014

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Vegetation Condition

Figure 6

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Data source: GA: Mainlands, Roads, Localities - 2007; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; MRWA: SLK - 20131219; GHD: Vegetation Condition - 20140617, Study Area, Impact Area - 20140617. Created by: bflorczak

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790,000 795,000 800,000 805,000

7,065,000 7,060,000 7,055,000

649 2-3 648 3 646 2-3 3 644 643 642 641 640 3 639 638 637 2-3 636 635 Goldfields Hwy 3 633 632 631 630 629 628 627 3 2 2-3 4 5 4 3

Vegetation Condition

- 1. Pristine or Nearly so
- 1-2
- 2. Excellent
- 2-3
- 3. Very Good
- 3-4
- 4. Good
- 4-5
- 5. Degraded
- 5-6
- 6. Completely Degraded

1:50,000 (at A3)

0 0.5 1 1.5 2 2.5

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map

1 MEEKATHARRA 2 3 4 5 6 7 8 9 WILUNA 10 11

Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Job Number	61-30097
Revision	0
Date	17 Sep 2014

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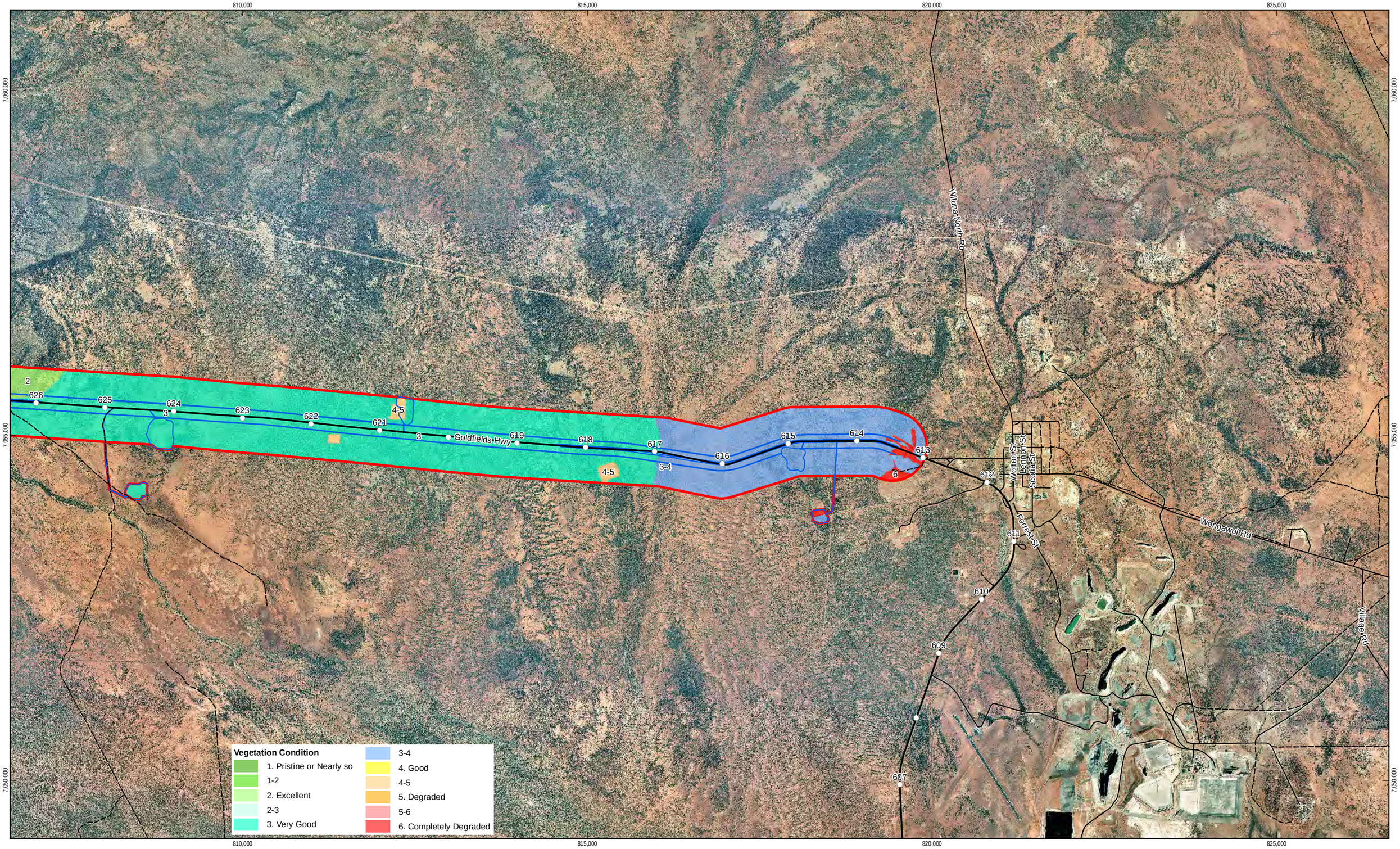
Figure 6

Vegetation Condition

G:\61\30097\GIS\Maps\MXD\6130097_G002_Fig6_Rev0.mxd

Data source: GA: Mainlands, Roads, Localities - 2007; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; MRWA: SLK - 20131219; GHD: Vegetation Condition - 20140617, Study Area, Impact Area - 20140617. Created by: bflorczak

239 Adelaide Terrace Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au



1:50,000 (at A3)

0 0.5 1 1.5 2 2.5

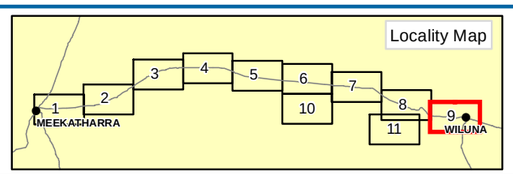
Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area



Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Job Number	61-30097
Revision	0
Date	17 Sep 2014

Sheet 9 of 11

Vegetation Condition

Figure 6

G:\61\30097\GIS\Maps\MXD\6130097_G002_Fig6_Rev0.mxd

Data source: GA: Mainlands, Roads, Localities - 2007; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; MRWA: SLK - 20131219; GHD: Vegetation Condition - 20140617, Study Area, Impact Area - 20140617. Created by: bflorczak

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750,000 755,000 760,000 765,000

7,060,000

7,055,000

2-3
3
3
2
6
3
4
3-4
3

Vegetation Condition

1. Pristine or Nearly so	3-4
1-2	4. Good
2. Excellent	4-5
2-3	5. Degraded
3. Very Good	5-6
	6. Completely Degraded

1:50,000 (at A3)

0 0.5 1 1.5 2 2.5

Kilometres

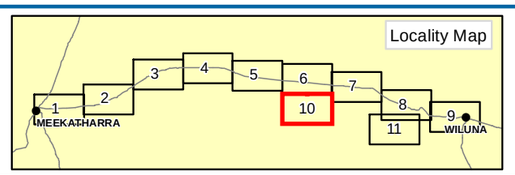
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map



Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Job Number	61-30097
Revision	0
Date	17 Sep 2014

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Figure 6

Vegetation Condition

239 Adelaide Terrace Perth WA 6004 Australia **T** 61 8 6222 8222 **F** 61 8 6222 8555 **E** permail@ghd.com.au **W** www.ghd.com.au

G:\61\30097\GIS\Maps\MXD\6130097_G002_Fig6_Rev0.mxd

Data source: GA: Mainlands, Roads, Localities - 2007; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; MRWA: SLK - 20131219; GHD: Vegetation Condition - 20140617, Study Area, Impact Area - 20140617. Created by: bflorczak

785,000 790,000 795,000 800,000

7,055,000

7,050,000

7,045,000

Vegetation Condition

- 1. Pristine or Nearly so
- 1-2
- 2. Excellent
- 2-3
- 3. Very Good
- 3-4
- 4. Good
- 4-5
- 5. Degraded
- 5-6
- 6. Completely Degraded

1:50,000 (at A3)

0 0.5 1 1.5 2 2.5

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map

1 MEEKATHARRA 2 3 4 5 6 7 8 9 WILUNA 10 11

Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Job Number	61-30097
Revision	0
Date	17 Sep 2014

Sheet 11 of 11

Figure 6

Vegetation Condition

239 Adelaide Terrace Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au

G:\61\30097\GIS\Maps\MXD\6130097_G002_Fig6_Rev0.mxd

Data source: GA: Mainlands, Roads, Localities - 2007; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; MRWA: SLK - 20131219; GHD: Vegetation Condition - 20140617, Study Area, Impact Area - 20140617. Created by: bflorczak

2.6.5 Conservation significant ecological communities

A search of the EPBC Act PMST database (DotE 2013d) did not identify any federally listed Threatened Ecological Community (TECs) within the Study Area. A search of the DPaW TEC and Priority Ecological Community (PEC) databases identified six PEC Calcrete Groundwater Assemblages (CGA) mapped within the Study Area, with three intersecting the Survey Area. These PECs are listed in Table 9 and mapped in Figure 3. In addition the desktop assessment of CGAs by Subterranean Ecology (2014) determined that numerous additional calcretes occur within the study Area which are also likely to harbour CGAs that would quality for listing as Priority 1 PECs. These have not been listed as PECs because they have not been sampled for stygofauna. CGAs are the ecological community or assemblage of subterranean invertebrates (typically stygofauna) that inhabit groundwater in calcrete.

The Subterranean Ecology report is provided in Appendix E.

No field surveys for the CGA PEC have been conducted. No additional TECs or PECs were recorded during the field survey.

Table 9 Priority ecological communities within the vicinity of the Survey Area

Community name	Description	Location relative to the Survey Area	
Killara Calcrete	Killara calcrete groundwater assemblage types on Murchison palaeodrainage on Killara Station	Priority 1	Killara station, intersecting the Survey Area between SLK 720-734
Millbillillie Bubble Well Calcrete	Millbillillie Bubble Well groundwater calcrete assemblage type on Carey palaeodrainage on Millbillillie Station	Priority 1	Bubble Creek area on Millbillillie station intersecting the Survey Area between SLK 625-644
Paroo Calcrete	Paroo calcrete groundwater assemblage type on Carey palaeodrainage on Paroo Station	Priority 1	Paroo station, intersecting the Survey Area between SLK 655-665
Wiluna BF Calcrete	Wiluna BF calcrete groundwater assemblage type on Carey palaeodrainage on Millbillillie Station	Priority 1	Six kilometres east of Wiluna
Uramurdah Calcrete	Uramurdah Lake calcrete groundwater assemblage type on Carey palaeodrainage on Millbillillie Station	Priority 1	Seven kilometres south-east of Wiluna
Lake Violet Calcrete	Lake Violet south and Lake Violet calcrete groundwater assemblage types on Carey palaeodrainage on Millbillillie Station	Priority 1	Six kilometres south of the Wiluna

670,000 715,000 760,000 805,000

7,080,000

KARALUNDI

Buttah Rd

Mooloogool Rd

Munarra Rd

Great Northern Hwy

Diamond Well-Doolgunna Rd

Paroo Rd

Wiluna North Rd

Goldfields Hwy

MEEKATHARRA

WILUNA

Murchison Downs Rd

Meekatharra-Sandstone Rd

Hillview-Murchison Downs Rd

Nannine-Polelle Rd

Young Downs Rd

Sandstone-Wiluna Rd

Yeelirrie Rd

Meekatharra-Yeelirrie Rd

7,035,000

670,000 715,000 760,000 805,000

1: 450,000 (at A3)

0 5 10 15 20 25

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

LEGEND

- Localities

Threatened and Priority Species (DPaW databases)

- (T) Threatened Flora - Extant Taxa
- Priority 1 - Poorly Known Taxa
- Priority 2 - Poorly Known Taxa
- Priority 3 - Poorly Known Taxa
- Priority 4 - Rare Taxa
- Priority 5 - Conservation Dependent Taxa
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

PEC Areas (DPaW 2013)

- Priority 1

Main Roads Western Australia
EIA and EMP for
Goldfields Highway Project

Job Number 61-30097
Revision 0
Date 16 Sep 2014

Priority Ecological Communities and previously recorded conservation significant flora

Figure 7

G:\61\30097\GIS\Maps\MXD\6130097_G007_Fig7_Rev0.mxd

Data source: DAFWA: Threatened and Priority Species, PEC Areas, 2013; Landgate: Roads - 20140611; GA: Localities 2007; GHD: Study Area, Impact Area - 20140617. Created by: ES

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2.6.6 Riparian vegetation

Two vegetation associations considered to support riparian vegetation were recorded in the Survey Area. These include *Eucalyptus* woodland (VA15) and *Acacia aptaneura* low woodland (VA02) which cover 251.2 ha and 83 ha respectively. Both vegetation associations were restricted to ephemeral drainage lines and adjacent floodplains, and supported riparian taxa.

Eucalyptus woodland was restricted to two small patches near SLK 660 and two parts in the Bubble Creek area. This association comprised *Eucalyptus camaldulensis* in the upper stratum over mid to low shrub layers and sparse ground layers. *Eucalyptus camaldulensis* is associated with riparian systems (Honczar & Thompson 2006) and obtains water from groundwater, rainfall and river flooding events, the latter enabling the species to survive in semi-arid regions. It is reported that *E. camaldulensis* trees that are exposed to prolonged drought-like conditions will respond by shedding leaf canopy, death of limbs, and curtailment of growth and replacement of the primary crown with epicormic growth (Batini 2008). Water stress of *E. camaldulensis* trees was evident near SLK 660 with a number of trees having dead limbs, reduced leaf canopies and limited new growth.

Acacia aptaneura low woodland was restricted to a number of clearly defined channels occurring near Meekatharra, SLK 733, SLK 736-738 and SLK 616.5. This association comprised *Acacia aptaneura* with ± *Hakea lorea* in the upper stratum over tall, mid and low shrub layers and sparse ground layers. *Hakea lorea* is considered a riparian species by Loomes (2010).

The vegetation condition of *Eucalyptus* woodland (VA15) and *Acacia aptaneura* low woodland (VA02) was rated as *Very Good* (3).

2.6.7 Other significant vegetation

The field survey identified vegetation that may be considered as significant due to reasons defined by the EPA (2004a) such as unusual species and a role as a refuge (described further in Appendix A). These vegetation types were restricted to very specific landforms and supported the majority of the priority species recorded in the field survey. The 'other significant vegetation' recorded during the field survey has been mapped at Figure 8 and detailed in Table 10.

Table 10 Vegetation associations mapped within the Survey Area classified as 'other significant vegetation'

Vegetation association	Reason for consideration as 'other significant vegetation'
VA05: Mixed low woodland on banded ironstone and chert hills	Scarcity; unusual combination of species
VA09: *Acacia burkittii* tall shrubland on quartz and ironstone hills	Scarcity; unusual combination of species
VA12: *Eremophila* low shrubland on low rocky hills	Scarcity
VA15: *Eucalyptus camaldulensis* woodland over mixed shrubland in ephemeral drainage lines and adjacent floodplains	Role as a refuge, supports large population of priority species *Stackhousia clementii* (Priority 3)
VA20: Mixed low shrubland on calcareous breakaways	Only occurs in isolated occurrences in the Survey Area and supported priority species including *Calytrix uncinata* (Priority 3) and *Gunniopsis propinqua* (Priority 3)

Vegetation association	Reason for consideration as 'other significant vegetation'
VA21: Mixed *Acacia* and *Eremophila* low shrubland on granite and quartz outcrops	Scarcity and this outcropping granite and associated vegetation type only occurred in this one restricted area within the Survey Area (total 19 ha) and supported a mixed low shrubland that included a number of species that were not recorded elsewhere, including *Indigofera* sp. Gilesii (M.E. Trudgen 15869) (Priority 3) and *Sauropus ramosissimus* (Priority 3)
VA22: Mixed *Acacia* tall shrubland on banded ironstone hills	Scarcity
VA23: Mixed low shrubland on outcrops	Scarcity
VA24: *Corymbia lenziana* open woodland on sand dunes	Scarcity; novel combination of species; restricted distribution; representative of the range of vegetation (outlier – generally occurs further east)
VA25: *Acacia rhodophloia* tall shrubland on chert hills	Scarcity; supports priority species – *Eremophila congesta* (Priority 1)

2.6.8 Diseases and pathogens

Phytophthora cinnamomi (Dieback) disease is generally restricted to areas of the south west of the State, south of the 26th parallel of latitude, in areas receiving an average annual rainfall of greater than 400 mm. The Survey Area is not considered to be susceptible to the development of the Dieback pathogen, this region only receives on average between 237 to 258 mm per annum.

Puccinia psidii sensu lato (Myrtle rust) is a fungus that causes disease in plants from the Myrtaceae family. There are no confirmed reports of Myrtle rust in Western Australia but DPaW is on the alert for this disease.

No diseases or pathogens of native flora were noted during the field survey.

2.7 Flora

2.7.1 Flora diversity[1]

A search of the *NatureMap* database (DPaW 2007–) identified 707 plant taxa, representing 62 families and 223 genera that have previously been recorded within the Study Area. This total comprised 683 native flora taxa and 24 naturalised (non-native) flora taxa. Dominant families within this search result included Fabaceae, Asteraceae and Scrophulariaceae.

A total of 398 flora taxa (including subspecies and varieties) representing 53 families and 154 genera were recorded in the Survey Area during the GHD field surveys. This total comprised 391 (98 %) native taxa and seven (2 %) introduced taxa.

Dominant families recorded from the Survey Area included:

- Fabaceae 63 taxa
- Poaceae 41 taxa
- Asteraceae 41 taxa
- Scrophulariaceae 39 taxa
- Chenopodiaceae 35 taxa

[1] A number of flora collections are currently pending identification at the Western Australian Herbarium. Flora diversity results are subject to change and will be updated when all flora collections IDs are completed.

Dominant genera recorded from the Survey Area included:

- *Acacia* 40 taxa
- *Eremophila* 39 taxa
- *Ptilotus* 14 taxa
- *Senna* 12 taxa
- *Maireana* 12 taxa

A flora list for the Survey Area is provided in Appendix D.

2.7.2 Conservation significant flora

Desktop searches of the EPBC Act PMST database (DotE 2013d), NatureMap database (DPaW 2007–), DPaW Threatened and Priority Flora database (TPFL) and Western Australian Herbarium database (WAHERB) identified the presence/potential presence of 33 conservation significant flora taxa within the Study Area (Appendix C and Figure 8). A review of data provided by Main Roads identified the presence/potential presence of an additional five conservation significant flora taxa. The desktop searches recorded:

- One EPBC Act/*Wildlife Conservation Act 1950* (WC Act) listed taxon
- Ten Priority 1 taxa
- 22 Priority 3 taxa
- Five Priority 4 taxa

Likelihood of occurrence

A likelihood of occurrence assessment, which takes into account previous records including date of record and proximity to Survey Area, species habitat requirements, recorded flowering times, cryptic nature of each taxon and efficacy of the field survey was completed for all conservation significant flora taxa identified in the desktop assessment (Appendix D).

This assessment concluded that four taxa are known to occur, seven taxa are likely to occur, 25 taxa may possibly occur and two taxa are unlikely to occur in the Survey Area.

Field survey

The GHD field survey did not record any EPBC Act or WC Act-listed flora taxa within the Survey Area, however, nine DPaW Priority-listed flora taxa were recorded. These were:

- *Eremophila congesta* (Priority 1)
- *Calytrix uncinata* (Priority 3)
- *Calytrix verruculosa* (Priority 3)
- *Gunniopsis propinqua* (Priority 3)
- *Homalocalyx echinulatus* (Priority 3)
- *Indigofera* sp. Gilesii (M.E. Trudgen 15869) (Priority 3)
- *Ptilotus luteolus* (Priority 3)
- *Sauropus ramosissimus* (Priority 3)
- *Stackhousia clementii* (Priority 3)

A brief description of each of these taxa is provided below (Source: WA Herbarium, 1998). The conservation significant flora species recorded during the field survey have been mapped at Figure 8.

Eremophila congesta (Priority 1)

Eremophila congesta is a densely branched, upright grey-green shrub, growing to 1.2 m high (WA Herbarium, 1998–). The species has purple-blue flowers in August and September (WA Herbarium, 1998–). *Eremophila congesta* grows in skeletal or red/deep orange brown sandy clay loam soils on lateritic outcrops in greenstone hills and on stony quartzite slopes in mulga woodland (WA Herbarium, 1998–). The species is known only from the Wiluna local government area, including at Mt Alice, where it is the dominant shrub just below the summit (Chinnock, 2007 and WA Herbarium, 1998–).

During the field survey *E. congesta* was recorded in Mixed *Acacia* tall shrubland on rocky footslopes (VA19) and *Acacia rhodophloia* tall shrubland on a chert hill (VA25). It is estimated that 588+ individuals occur within the Survey Area with a further 159+ occurring adjacent to the Survey Area. It is possible that more individuals occur scattered throughout the Survey Area within Mixed *Acacia* tall shrubland on rocky footslopes (VA19).

Plate 2 *Eremophila congesta* in situ

Calytrix uncinata (Priority 3)

Calytrix uncinata is a shrub, growing from 0.3 m to one metre high and 1.5 m wide. The species has white flowers from August to November. *C. uncinata* grows in white or red sand, sandy clay on granite or sandstone breakaways, on Banded Ironstone and rocky rises in mulga shrubland (WA Herbarium, 1998–). The species has previously been recorded within the local government areas of Leonora, Meekatharra, Menzies, Mount Magnet, Sandstone, Wiluna, Yalgoo (WA Herbarium, 1998–).

During the field survey *C. uncinata* was recorded in mixed low shrubland on calcareous breakaways (VA20) near SLK 778. A total of 17 individuals were recorded on and adjacent to calcareous breakaways within the Survey Area.

Plate 3 *Calytrix uncinata* in situ

Calytrix verruculosa (Priority 3)

Calytrix verruculosa is a shrub, growing from 0.3 to one metre high. The species has pink/white flowers in August to October (WA Herbarium 1998–). *C. verruculosa* grows in sandy clay on rocky slopes, valleys and flats in mulga shrubland and scrub. The species has previously been recorded within the local government areas of Cue, Meekatharra and Murchison (WA Herbarium 1998–).

During the field survey *C.verruculosa* was recorded in mixed tall shrubland on stony plains (VA01) near SLK 781. A total of 75 individuals were recorded within the Survey Area. These plants were recorded on shallow soils in decomposed gravel.

Plate 4 *Calytrix verruculosa* in situ

Gunniopsis propinqua (Priority 3)

Gunniopsis propinqua is a prostrate annual or perennial herb to 0.1 m high. This species has white or pink flowers from August to September. It occurs in stony sandy loam, lateritic outcrops and in winter-wet sites (WA Herbarium 1998). This species has been recorded from scattered locations in the IBRA regions of Gascoyne, Murchison, Pilbara and Yalgoo.

This species was recorded in two locations within and adjacent to the vegetation type VA20 ‘Mixed low shrubland on calcareous breakaways’

Plate 5 *Gunniopsis propinqua* in situ

Homalocalyx echinulatus (Priority 3)

Homalocalyx echinulatus is a shrub, growing from 0.45 to one metre high with characteristically toothed leaf margins (Craven 1987 and WA Herbarium 1998–). The species has pink flowers from June to September (WA Herbarium 1998). *H. echinulatus* grows in sandy loam or clay, or laterite, on rocky hills, breakaways and Banded Ironstone (Craven 1987 and WA Herbarium 1998). The species was first collect in July 1931 by CA Gardner west of Meekatharra and has also previously been recorded within the local government areas of Cue, Murchison, Sandstone and Wiluna (WA Herbarium 1998).

Homalocalyx echinulatus was recorded in one location during the field survey upper slope with chert blocks with *Eremophila congesta* (P1).

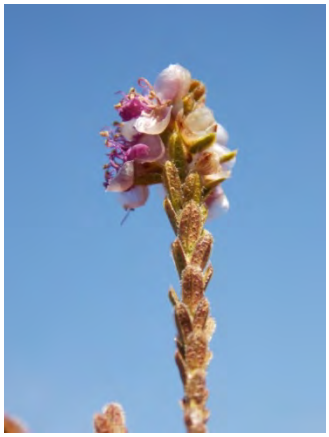

Plate 6 *Homalocalyx echinulatus* in situ

Indigofera sp. Gilesii (M.E. Trudgen 15869) (Priority 3)

Indigofera sp. Gilesii (M.E. Trudgen 15869) is a shrub, growing to 1.6 m high with characteristically spiny stipules. The species has salmon to deep pink or purple/red flowers in May to August.*I.* sp Gilesii (M.E. Trudgen 15869) grows in red/brown skeletal, stony loamy/sandy soils on gorges, gullies, hilltops, creeklines and sandplains in low trees/shrubland and grasslands. The species has previously been recorded within the local government areas of Ashburton, East Pilbara, Halls Creek, Meekatharra and Ngaanyatjarraku (WA Herbarium 1998–).

This species was recorded in one location within the Survey Area on a granite outcrop on the southern side to the existing highway (VA21) at approximately SLK 738.4. As well as an isolated occurrence on the northern side of the highway in this same location This outcropping granite and associated vegetation type only occurred in this one restricted area within the Survey Area (total 19 ha) and supported a mixed low shrubland that included a number of species that were not recorded elsewhere, including *Sauropus ramosissimus* (Priority 3 – discussed below). Twelve *I.* sp Gilesii plants were recorded within this area.

Plate 7 *Indigofera* sp. Gilesii (M.E. Trudgen 15869) in situ

Ptilotus luteolus (Priority 3)

Ptilotus luteolus is an erect compact woody subshrub, growing to 30 cm high and 40 cm across. The species has greenish-yellow flowers in June, August and September (WA Herbarium, 1998–). *P. luteolus* grows in shallow orange/brown clay loams or sandy soils on rocky slopes, screes and ridges in the southern Gascoyne and Murchison IBRA regions (Davis, 2009). The species has previously been recorded within the local government areas of Carnarvon, Meekatharra, Mount Magnet, Upper Gascoyne and Wiluna (WA Herbarium, 1998–).

During the field survey *P. luteolus* was recorded in the material pit at SLK614. A total of two individuals were recorded within the material pit with a third individual recorded outside of the material pit but on the edge of the track to the pit.

Plate 8 *Ptilotus luteolus* in situ

Sauropus ramosissimus (Priority 3)

Sauropus ramosissimus is a slender, much-branched shrub to 0.3 m high. This species occurs within the Gibson Desert and Great Victoria Desert to the east and south of Wiluna. This species has generally been recorded within gravelly ironstone soils, rocky pavements and lateritic pavements (WA Herbarium, 1998–).

This species was recorded in one location within the Survey Area on a granite outcrop on the southern side to the existing highway (VA21) at approximately SLK 738.4. This outcropping granite and associated vegetation type only occurred in this one restricted area within the Survey Area (total 19 ha) and supported a mixed low shrubland that included a number of species that were not recorded elsewhere, including *Indigofera* sp. Gilesii (Priority 3 – discussed above). Six plants were recorded within this area.

Plate 9 *Sauropus ramosissimus* in situ

Stackhousia clementii (Priority 3)

Stackhousia clementii is a dense broom-like perennial herb, growing to 45 cm high and 30 cm wide. The species has green/yellow/brown flowers in April and August. *S. clementii* grows in dark red/brown clay or skeletal soils on sandstone/limestone hills or hills, rocky plains and along creeklines in mulga shrubland and riparian zones. The species has previously been recorded within the local government areas of Ashburton, Carnarvon, Ngaanyatjarraku, Roebourne and Wiluna (WA Herbarium, 1998–).

During the field survey *S. clementii* was recorded in *Eucalyptus* woodland (VA15) vegetation association in the Bubble Creek area. At this location many individuals were recorded on the floodplain with counts averaging 180 individuals per 100 m^2.

Plate 10 *Stackhousia clementii* in situ

2.7.3 Other significant flora

The flora species recorded during the field surveys were assessed to determine whether any were regarded as other 'significant flora' as defined by the EPA (2004a). No new or potentially new species were recorded during the field assessments within the Survey Area; however, one specimen had anomalous or indistinct features and was unable to be sufficiently identified. These taxa were submitted to the Western Australian Herbarium (Accession 5735) for verification and one was subsequently identified as *Wahlenbergia gracilenta* which is a genus that is in need of revision in Western Australia. As such, the identification is tentative. This species is poorly known from the vicinity of the Study Area with the closest records being approximately 150 km west of the Survey Area. The field surveys recorded one species that was considered as a range extension: *Pterocaulon sphacelatum*. This species was recorded once within the Survey Area and its location mapped at Figure 8. The closest record of this species on NatureMap is approximately 150 km to the north of the Survey Area.

650,000 655,000 660,000 665,000

7,060,000

Great Northern Hwy

Goldfields Hwy

Main St
High St
Hill St
Daroldst
Railway St
Campbell Rd
Mecleary St
Meekatharra-Sandstone Rd

793 792 791 790 789 788 787 786 785 784 783 782 781 780 779 778 777 776 775

20

7,055,000

Priority Species (GHD)

- *Eremophila congesta* (Priority 1)
- *Homalocalyx echinulatus* (Priority 3)
- *Ptilotus luteolus* (Priority 3)
- *Stackhousia clementii* (Priority 3)
- *Calytrix verruculosa* (Priority 3)
- *Calytrix uncinata* (Priority 3)
- *Gunniopsis propinqua* (Priority 3)
- *Indigofera* sp. Gilesii (M.E. Trudgen 15869) (Priority 3)
- *Sauropus ramosissimus* (Priority 3)

Other Significant Flora (GHD)

- *Pterocaulon sphacelatum* Range Extension

Other Significant Vegetation (GHD)

- VA05: Mixed low woodland on banded ironstone and chert hills
- VA09: *Acacia burkittii* tall shrubland on quartz and ironstone hills
- VA12: *Eremophila* low shrubland on low rocky hills
- VA15: *Eucalyptus camaldulensis* woodland over mixed shrubland in ephemeral drainage lines and adjacent floodplains
- VA20: Mixed low shrubland on calcareous breakaways
- VA21: Mixed *Acacia* and *Eremophila* low shrubland on granite and quartz outcrops
- VA22: Mixed *Acacia* tall shrubland on banded ironstone hills
- VA23: Mixed low shrubland on outcrops
- VA24: *Corymbia lenziana* open woodland on sand dunes

650,000 655,000 660,000 665,000

1:50,000 (at A3)

0 0.5 1 1.5 2 2.5

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map

1 MEEKATHARRA 2 3 4 5 6 7 8 9 WILUNA 10 11

Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Job Number 61-30097
Revision 0
Date 17 Sep 2014

Conservation significant vegetation and flora

Figure 8

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Data source: GA: Topo 250k Series 3 - 2006; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; MRWA: SLK Marker - 20131219; GHD: Impact Area, Study Area, Priority Species, Taxon, Other Significant Flora, Other Significant Vegetation - 20140617. Created by: bflorczak

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670,000 675,000 680,000 685,000

7,065,000

7,060,000

753 754 755 756 757 758 759 760 761 762 763 765 766 767 768 769 770 771 772 773 774 20 22

Goldfields Hwy

Priority Species (GHD)

- *Eremophila congesta* (Priority 1)
- *Homalocalyx echinulatus* (Priority 3)
- *Ptilotus luteolus* (Priority 3)
- *Stackhousia clementii* (Priority 3)
- *Calytrix verruculosa* (Priority 3)
- *Calytrix uncinata* (Priority 3)
- *Gunniopsis propinqua* (Priority 3)
- *Indigofera* sp. Gilesii (M.E. Trudgen 15869) (Priority 3)
- *Sauropus ramosissimus* (Priority 3)

Other Significant Flora (GHD)

- *Pterocaulon sphacelatum* Range Extension

Other Significant Vegetation (GHD)

- VA05: Mixed low woodland on banded ironstone and chert hills
- VA09: *Acacia burkittii* tall shrubland on quartz and ironstone hills
- VA12: *Eremophila* low shrubland on low rocky hills
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- VA21: Mixed *Acacia* and *Eremophila* low shrubland on granite and quartz outcrops
- VA22: Mixed *Acacia* tall shrubland on banded ironstone hills
- VA23: Mixed low shrubland on outcrops
- VA24: *Corymbia lenziana* open woodland on sand dunes

1:50,000 (at A3)

0 0.5 1 1.5 2 2.5

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map

1 MEEKATHARRA 2 3 4 5 6 7 8 9 WILUNA 10 11

Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Job Number 61-30097
Revision 0
Date 17 Sep 2014

Conservation significant vegetation and flora

Figure 8

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690,000 695,000 700,000 705,000

7,075,000

7,070,000

Goldfields Hwy

731 732 734 735 736 737 738 739 740 741 742 744 745 746 747 748 749 750 751 752

20 21 23 24

Priority Species (GHD)

- *Eremophila congesta* (Priority 1)
- *Homalocalyx echinulatus* (Priority 3)
- *Ptilotus luteolus* (Priority 3)
- *Stackhousia clementii* (Priority 3)
- *Calytrix verruculosa* (Priority 3)
- *Calytrix uncinata* (Priority 3)
- *Gunniopsis propinqua* (Priority 3)
- *Indigofera* sp. Gilesii (M.E. Trudgen 15869) (Priority 3)
- *Sauropus ramosissimus* (Priority 3)

Other Significant Flora (GHD)

- *Pterocaulon sphacelatum* Range Extension

Other Significant Vegetation (GHD)

- VA05: Mixed low woodland on banded ironstone and chert hills
- VA09: *Acacia burkittii* tall shrubland on quartz and ironstone hills
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- VA21: Mixed *Acacia* and *Eremophila* low shrubland on granite and quartz outcrops
- VA22: Mixed *Acacia* tall shrubland on banded ironstone hills
- VA23: Mixed low shrubland on outcrops
- VA24: *Corymbia lenziana* open woodland on sand dunes

690,000 695,000 700,000 705,000

1:50,000 (at A3)

0 0.5 1 1.5 2 2.5

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map

1 MEEKATHARRA 2 3 4 5 6 7 8 9 WILUNA 10 11

Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Job Number 61-30097
Revision 0
Date 17 Sep 2014

Conservation significant vegetation and flora

Sheet 3 of 11

Figure 8

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710,000 715,000 720,000 725,000

7,080,000 7,075,000 7,070,000

9 9 22

730 729 728 727 726 725 724 723 722 721 720 719 718 717 716 715 714 713 712 711

Goldfields Hwy

Priority Species (GHD)

- *Eremophila congesta* (Priority 1)
- *Homalocalyx echinulatus* (Priority 3)
- *Ptilotus luteolus* (Priority 3)
- *Stackhousia clementii* (Priority 3)
- *Calytrix verruculosa* (Priority 3)
- *Calytrix uncinata* (Priority 3)
- *Gunniopsis propinqua* (Priority 3)
- *Indigofera* sp. Gilesii (M.E. Trudgen 15869) (Priority 3)
- *Sauropus ramosissimus* (Priority 3)

Other Significant Flora (GHD)

- *Pterocaulon sphacelatum* Range Extension

Other Significant Vegetation (GHD)

- VA05: Mixed low woodland on banded ironstone and chert hills
- VA09: *Acacia burkittii* tall shrubland on quartz and ironstone hills
- VA12: *Eremophila* low shrubland on low rocky hills
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- VA21: Mixed *Acacia* and *Eremophila* low shrubland on granite and quartz outcrops
- VA22: Mixed *Acacia* tall shrubland on banded ironstone hills
- VA23: Mixed low shrubland on outcrops
- VA24: *Corymbia lenziana* open woodland on sand dunes

710,000 715,000 720,000 725,000

1:50,000 (at A3)

0 0.5 1 1.5 2 2.5

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map

1 MEEKATHARRA 2 3 4 5 6 7 8 9 WILUNA 10 11

Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Job Number 61-30097
Revision 0
Date 17 Sep 2014

Conservation significant vegetation and flora

Sheet 4 of 11

Figure 8

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Data source: GA: Topo 250k Series 3 - 2006; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; MRWA: SLK Marker - 20131219; GHD: Impact Area, Study Area, Priority Species, Taxon, Other Significant Flora, Other Significant Vegetation - 20140617. Created by: bflorczak

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730,000 735,000 740,000 745,000

7,075,000

7,070,000

Diamond Well-Doolgunna Rd

Goldfields Hwy

710 709 708 707 706 705 704 703 701 700 699 698 697 696 695 694 693 692 691

Priority Species (GHD)

- *Eremophila congesta* (Priority 1)
- *Homalocalyx echinulatus* (Priority 3)
- *Ptilotus luteolus* (Priority 3)
- *Stackhousia clementii* (Priority 3)
- *Calytrix verruculosa* (Priority 3)
- *Calytrix uncinata* (Priority 3)
- *Gunniopsis propinqua* (Priority 3)
- *Indigofera* sp. Gilesii (M.E. Trudgen 15869) (Priority 3)
- *Sauropus ramosissimus* (Priority 3)

Other Significant Flora (GHD)

- *Pterocaulon sphacelatum* Range Extension

Other Significant Vegetation (GHD)

- VA05: Mixed low woodland on banded ironstone and chert hills
- VA09: *Acacia burkittii* tall shrubland on quartz and ironstone hills
- VA12: *Eremophila* low shrubland on low rocky hills
- VA15: *Eucalyptus camaldulensis* woodland over mixed shrubland in ephemeral drainage lines and adjacent floodplains
- VA20: Mixed low shrubland on calcareous breakaways
- VA21: Mixed *Acacia* and *Eremophila* low shrubland on granite and quartz outcrops
- VA22: Mixed *Acacia* tall shrubland on banded ironstone hills
- VA23: Mixed low shrubland on outcrops
- VA24: *Corymbia lenziana* open woodland on sand dunes

730,000 735,000 740,000 745,000

1:50,000 (at A3)

0 0.5 1 1.5 2 2.5

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map

1 MEEKATHARRA 2 3 4 5 6 7 8 9 WILUNA 10 11

Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Job Number 61-30097
Revision 0
Date 17 Sep 2014

Conservation significant vegetation and flora

Sheet 5 of 11

Figure 8

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Data source: GA: Topo 250k Series 3 - 2006; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; MRWA: SLK Marker - 20131219; GHD: Impact Area, Study Area, Priority Species, Taxon, Other Significant Flora, Other Significant Vegetation - 20140617. Created by: bflorczak

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750,000 755,000 760,000 765,000

7,075,000 7,070,000 7,065,000

Priority Species (GHD)

- *Eremophila congesta* (Priority 1)
- *Homalocalyx echinulatus* (Priority 3)
- *Ptilotus luteolus* (Priority 3)
- *Stackhousia clementii* (Priority 3)
- *Calytrix verruculosa* (Priority 3)
- *Calytrix uncinata* (Priority 3)
- *Gunniopsis propinqua* (Priority 3)
- *Indigofera* sp. Gilesii (M.E. Trudgen 15869) (Priority 3)
- *Sauropus ramosissimus* (Priority 3)

Other Significant Flora (GHD)

- *Pterocaulon sphacelatum* Range Extension

Other Significant Vegetation (GHD)

- VA05: Mixed low woodland on banded ironstone and chert hills
- VA09: *Acacia burkittii* tall shrubland on quartz and ironstone hills
- VA12: *Eremophila* low shrubland on low rocky hills
- VA15: *Eucalyptus camaldulensis* woodland over mixed shrubland in ephemeral drainage lines and adjacent floodplains
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- VA22: Mixed *Acacia* tall shrubland on banded ironstone hills
- VA23: Mixed low shrubland on outcrops
- VA24: *Corymbia lenziana* open woodland on sand dunes

690 689 688 687 686 685 684 683 682 681 679 678 677 676 675 674 673 672 671

20 12 20 12

Goldfields Hwy

1:50,000 (at A3)

0 0.5 1 1.5 2 2.5

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map

1 MEEKATHARRA 2 3 4 5 6 7 8 9 WILUNA 10 11

Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Job Number 61-30097
Revision 0
Date 17 Sep 2014

Conservation significant vegetation and flora

Sheet 6 of 11

Figure 8

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Data source: GA: Topo 250k Series 3 - 2006; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; MRWA: SLK Marker - 20131219; GHD: Impact Area, Study Area, Priority Species, Taxon, Other Significant Flora, Other Significant Vegetation - 20140617. Created by: bflorczak

770,000 775,000 780,000 785,000

7,070,000

Paroo Rd

670 669 668 667 666 665 664 663 662 661 15 Goldfields Hwy 659 658 657 656 655 654 5 653 652 651 650

7,065,000

Priority Species (GHD)

- *Eremophila congesta* (Priority 1)
- *Homalocalyx echinulatus* (Priority 3)
- *Ptilotus luteolus* (Priority 3)
- *Stackhousia clementii* (Priority 3)
- *Calytrix verruculosa* (Priority 3)
- *Calytrix uncinata* (Priority 3)
- *Gunniopsis propinqua* (Priority 3)
- *Indigofera* sp. Gilesii (M.E. Trudgen 15869) (Priority 3)
- *Sauropus ramosissimus* (Priority 3)

Other Significant Flora (GHD)

- *Pterocaulon sphacelatum* Range Extension

Other Significant Vegetation (GHD)

- VA05: Mixed low woodland on banded ironstone and chert hills
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- VA23: Mixed low shrubland on outcrops
- VA24: *Corymbia lenziana* open woodland on sand dunes

1:50,000 (at A3)

0 0.5 1 1.5 2 2.5

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map

1 MEEKATHARRA 2 3 4 5 6 7 8 9 WILUNA 10 11

Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Job Number 61-30097
Revision 0
Date 17 Sep 2014

Conservation significant vegetation and flora

Sheet 7 of 11

Figure 8

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Data source: GA: Topo 250k Series 3 - 2006; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; MRWA: SLK Marker - 20131219; GHD: Impact Area, Study Area, Priority Species, Taxon, Other Significant Flora, Other Significant Vegetation - 20140617. Created by: bflorczak

790,000 795,000 800,000 805,000

7,065,000 7,060,000 7,055,000

Priority Species (GHD)

- *Eremophila congesta* (Priority 1)
- *Homalocalyx echinulatus* (Priority 3)
- *Ptilotus luteolus* (Priority 3)
- *Stackhousia clementii* (Priority 3)
- *Calytrix verruculosa* (Priority 3)
- *Calytrix uncinata* (Priority 3)
- *Gunniopsis propinqua* (Priority 3)
- *Indigofera* sp. Gilesii (M.E. Trudgen 15869) (Priority 3)
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Other Significant Flora (GHD)

- *Pterocaulon sphacelatum* Range Extension

Other Significant Vegetation (GHD)

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649 648 647 646 645 644 643 642 641 640 639 638 637 636 635 634 633 632 631 630 629 628 627

Goldfields Hwy

15

1:50,000 (at A3)

0 0.5 1 1.5 2 2.5

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map

1 MEEKATHARRA 2 3 4 5 6 7 8 9 WILUNA 10 11

Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Job Number 61-30097
Revision 0
Date 17 Sep 2014

Conservation significant vegetation and flora

Figure 8

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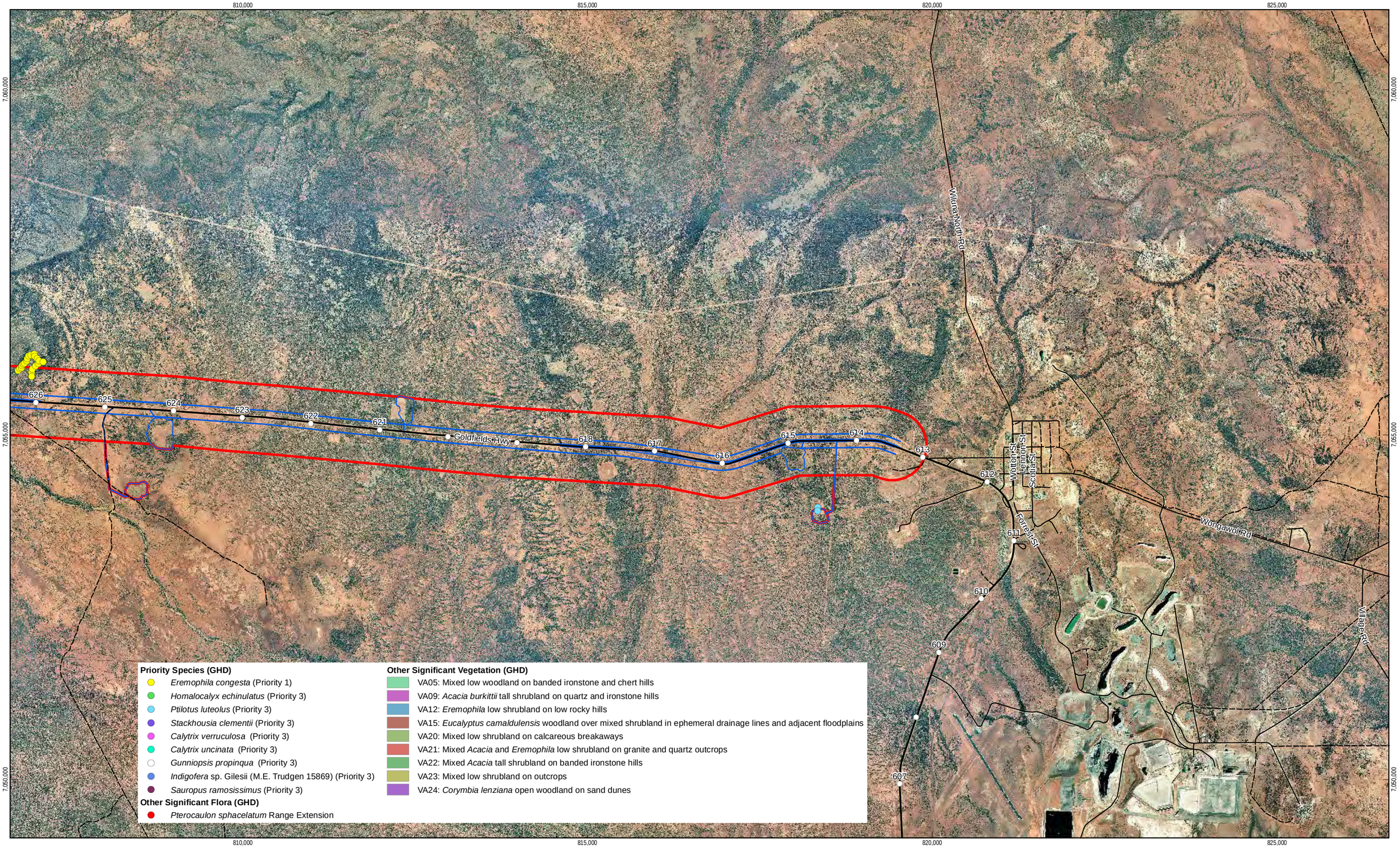


1:50,000 (at A3)

0 0.5 1 1.5 2 2.5

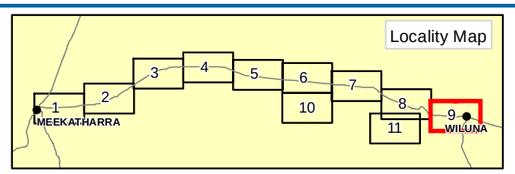
Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area



Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Job Number	61-30097
Revision	0
Date	17 Sep 2014

Conservation significant vegetation and flora

Figure 8

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750,000 755,000 760,000 765,000

7,060,000

7,055,000

Priority Species (GHD)

- *Eremophila congesta* (Priority 1)
- *Homalocalyx echinulatus* (Priority 3)
- *Ptilotus luteolus* (Priority 3)
- *Stackhousia clementii* (Priority 3)
- *Calytrix verruculosa* (Priority 3)
- *Calytrix uncinata* (Priority 3)
- *Gunniopsis propinqua* (Priority 3)
- *Indigofera* sp. Gilesii (M.E. Trudgen 15869) (Priority 3)
- *Sauropus ramosissimus* (Priority 3)

Other Significant Flora (GHD)

- *Pterocaulon sphacelatum* Range Extension

Other Significant Vegetation (GHD)

- VA05: Mixed low woodland on banded ironstone and chert hills
- VA09: *Acacia burkittii* tall shrubland on quartz and ironstone hills
- VA12: *Eremophila* low shrubland on low rocky hills
- VA15: *Eucalyptus camaldulensis* woodland over mixed shrubland in ephemeral drainage lines and adjacent floodplains
- VA20: Mixed low shrubland on calcareous breakaways
- VA21: Mixed *Acacia* and *Eremophila* low shrubland on granite and quartz outcrops
- VA22: Mixed *Acacia* tall shrubland on banded ironstone hills
- VA23: Mixed low shrubland on outcrops
- VA24: *Corymbia lenziana* open woodland on sand dunes

12

750,000 755,000 760,000 765,000

1:50,000 (at A3)

0 0.5 1 1.5 2 2.5

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map

1 MEEKATHARRA 2 3 4 5 6 7 8 9 WILUNA 10 11

Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Job Number	61-30097
Revision	0
Date	17 Sep 2014

Conservation significant vegetation and flora

Sheet 10 of 11

Figure 8

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Data source: GA: Topo 250k Series 3 - 2006; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; MRWA: SLK Marker - 20131219; GHD: Impact Area, Study Area, Priority Species, Taxon, Other Significant Flora, Other Significant Vegetation - 20140617. Created by: bflorczak

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785,000 790,000 795,000 800,000

7,055,000

7,050,000

7,045,000

Priority Species (GHD)

- *Eremophila congesta* (Priority 1)
- *Homalocalyx echinulatus* (Priority 3)
- *Ptilotus luteolus* (Priority 3)
- *Stackhousia clementii* (Priority 3)
- *Calytrix verruculosa* (Priority 3)
- *Calytrix uncinata* (Priority 3)
- *Gunniopsis propinqua* (Priority 3)
- *Indigofera* sp. Gilesii (M.E. Trudgen 15869) (Priority 3)
- *Sauropus ramosissimus* (Priority 3)

Other Significant Flora (GHD)

- *Pterocaulon sphacelatum* Range Extension

Other Significant Vegetation (GHD)

- VA05: Mixed low woodland on banded ironstone and chert hills
- VA09: *Acacia burkittii* tall shrubland on quartz and ironstone hills
- VA12: *Eremophila* low shrubland on low rocky hills
- VA15: *Eucalyptus camaldulensis* woodland over mixed shrubland in ephemeral drainage lines and adjacent floodplains
- VA20: Mixed low shrubland on calcareous breakaways
- VA21: Mixed *Acacia* and *Eremophila* low shrubland on granite and quartz outcrops
- VA22: Mixed *Acacia* tall shrubland on banded ironstone hills
- VA23: Mixed low shrubland on outcrops
- VA24: *Corymbia lenziana* open woodland on sand dunes

785,000 790,000 795,000 800,000

1:50,000 (at A3)

0 0.5 1 1.5 2 2.5

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map

1 MEEKATHARRA 2 3 4 5 6 7 8 9 WILUNA 10 11

Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

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Figure 8

G:\61\30097\GIS\Maps\MXD\6130097_G008_Fig8_Rev0.mxd

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2.7.4 Introduced flora (weeds)

A search of the *NatureMap* database (DPaW 2007–) identified 24 naturalised (non-native) flora taxa within the Study Area. None of these taxa are Declared Pests or Weeds of National Significance (WoNS).

The GHD field survey recorded seven introduced taxa during the field survey, these included:

- **Acetosa vesicaria*
- **Bidens pinnata (*Bipinnate Begger's Tick)
- **Cenchrus ciliaris* (Buffel Grass)
- **Citrullus lanatus* (Pie Melon)
- **Cuscuta planiflora*
- **Lysimachia arvensis*
- **Setaria verticillata*

All introduced taxa were recorded in small densities in isolated occurrences scattered throughout the Survey Area.

2.8 Fauna

2.8.1 Habitat types

Eight broad fauna habitat types were identified in the Survey Area, based on predominant landforms, soil and vegetation structure in the area (Figure 9). The structure and condition of the habitat types varied depending on the level of impact from various disturbances including cattle grazing, fire and past clearing. The habitat types closely correspond to the vegetation associations described in section 2.6.3, but represent a much broader description of the vegetation and landforms, and their value as habitat for fauna species. The habitat types are:

- *Acacia* shrubland over tussock grasses
- *Acacia* shrubland over hummock grasses
- Mixed shrubland
- Tussock grassland
- Chenopod shrubland
- *Eucalyptus*/*Corymbia* woodland (including riparian habitat around Bubble Creek)
- Rocky outcrops, breakaways and Banded Ironstone Formation (BIF) hills
- Sand dune

Plate 11 *Acacia* shrubland over spinifex grassland habitat

Acacia shrublands are the most dominant habitat type within the Survey Area, comprising a variety of different vegetation types including open *Acacia* shrublands with sparse hummocks (Plate 11), denser areas of tall *Acacia* shrubland with little understorey, as well as *Acacia* shrublands over scattered tussock grasses. A large proportion of the *Acacia* shrublands has been previously disturbed by cattle grazing, resulting in large areas with very limited understorey or groundcover vegetation. There are also areas with little evidence of disturbance, which retain some structural diversity. In areas where the shrubland is denser, this vegetation would provide suitable habitat for a variety of fauna species, in particular foraging opportunities, breeding habitat and refugia for birds such as the threatened Malleefowl (*Leipoa ocellata*) at the Wiluna end of the Survey Area. Where the shrubland is more open, and on loamy soils, this would provide suitable habitat for the Priority 1 listed Good-legged Lerista skink (*Lerista eupoda*).

Plate 12 Tussock grassland habitat

In most areas, the understorey of the *Acacia* shrublands consists of tussock grasses and patches that are quite open with scattered low shrubs and bare ground (Plate 12. This vegetation would provide foraging habitat for small to medium birds as well as reptiles such as monitors, skinks and snakes. Less frequent are areas of *Acacia* shrubland with a hummock grassland understorey (Plate 13). These hummocks vary from large, mature, well-spaced clumps, to young, small patches of regrowth, and provide a key habitat feature for a number of fauna species such as small ground-dwelling mammals such as native hopping mice, and the Priority 4 listed Brush-tailed Mulgara (*Dasycercus blythi*) (recorded in this habitat type). Australian Bustard (*Ardeotis australis*) (Priority 4) prints were also recorded in these areas. Mature clumps of hummock grasses also provide valuable refugia for a variety of reptile species such as skinks, dragons and snakes. The areas with patches of mature hummock grasses, mostly with only scattered *Acacia* shrubs, are mapped in Figure 9.

Plate 13 Spinifex hummock grassland habitat

Throughout the Survey Area there are some small patches of tussock grasslands which are dominated by sparse tussocks grasses and some scattered medium to tall shrubs (Plate 14). Throughout the lower lying areas are also some small patches of chenopod shrublands (Plate 15). These shrublands occur on the sandy clay plains, and provide some limited habitat for fauna species such as shelter for small reptiles (skinks and dragons).

Plate 14 Tussock grassland habitat

Plate 15 Chenopod shrubland habitat

On the floodplains and surrounding the ephemeral Bubble Creek, there is also a small area of *Eucalyptus camaldulensis* open woodland (Plate 16). This woodland would provide a variety of habitat resources for fauna species, and generally has a greater structural diversity than the surrounding shrublands. The *Acacia* shrublands that occur on the floodplains surrounding Bubble Creek would also provide good habitat for burrowing species given the looser sandy substrate. There is also one small patch of *Corymbia* woodland on a small dune around SLK 732 on the northern side of the highway. This dune provides suitable habitat for a variety of fauna species, including ground-dwelling mammals and fossorial reptiles.

Plate 16 *Eucalyptus/Corymbia* woodland habitat

Rocky habitat also occurs in isolated areas throughout the Survey Area. This rocky habitat includes rocky outcrops (Plate 17), breakaways (mostly calcareous), a small gorge and BIF hills (including Mt Russell) (Plate 18). These rocky areas provide valuable refuge habitat for fauna species such as the Priority 4 listed Long-tailed Dunnart (*Sminthopsis longicaudata*).

Plate 17 Rocky gorge habitat

Plate 18 Rocky slope habitat

The Survey Area also contains some areas that have been cleared or highly disturbed. These areas provide little to no habitat value and principally comprise of borrow pits, roads, vehicle tracks, cattle yards and other infrastructure.

2.8.2 Habitat value

The habitat present within the Survey Area provides a variety of resources for fauna species. While a large proportion of these habitats has been heavily disturbed as a result of grazing, there are some areas which retain valuable resources for fauna species, including conservation significant fauna. The value of the habitat for fauna species is summarised in Table 11 and should be considered in association witht the vegetation (habitat) condition mapped in Figure 6.

Table 11 Fauna habitat value

Habitat type	Habitat value	Reasoning	Conservation significant fauna habitat
Acacia shrubland over tussock grasses	Medium	Areas with minimal disturbance have good vegetation structure	Malleefowl (where *Acacia* shrubs are more dense) Good-legged Lerista skink Australian Bustard Bush Stone-curlew Grey Falcon Peregrine Falcon
Acacia shrubland over hummock grasses	High	Areas with minimal disturbance have good vegetation structure	Brush-tailed Mulgara Good-legged Lerista skink Australian Bustard Bush Stone-curlew Grey Falcon Peregrine Falcon Striated Grasswren
Mixed shrubland	Moderate	Areas with minimal disturbance have good vegetation structure	Australian Bustard Bush Stone-curlew Grey Falcon Peregrine Falcon
Tussock grassland	Low	Limited vegetation structure	Grey Falcon Peregrine Falcon
Chenopod shrubland	Low	Limited vegetation structure	Grey Falcon Peregrine Falcon
Eucalyptus/ *Corymbia* woodland	High	Good structural diversity and variety of habitat resources	Good-legged Lerista skink Grey Falcon Peregrine Falcon Major Mitchell's Cockatoo (riparian habitat)
Rocky outcrops and breakaways	High	Isolated habitat in the area	Long-tailed Dunnart Grey Falcon Peregrine Falcon
Sand dune	High	Rare habitat in the area	Northern Marsupial Mole (potentially, although unlikely) Grey Falcon Peregrine Falcon

2.8.4 Habitat linkages

Habitat linkages are important to allow animals to move between areas of resource availability. They are important for ground and aerial fauna, providing cover, resources, and linking areas suitable for rest and reproduction. Fragmentation of habitat limits the resources available to species, particularly sedentary species, which means they may be more vulnerable to natural disasters or habitat changes over time. Fragmentation of habitat can lead to edge effects, leading to degradation of the habitat. Where the distance between habitat fragments is small, species may still be able to move between these areas, but may be more exposed to predation pressures in the cleared areas.

Overall, the habitats within the Survey Area are well connected both locally and regionally to other areas of habitat. The majority of the Survey Area has previously been grazed and therefore the habitats have experienced various levels of disturbance resulting in some areas being highly degraded. Patches of habitat with good vegetation structure form a mosaic with highly degraded habitat, which may reduce the ability of some fauna species to move through the landscape at a local scale.

2.8.5 Fauna diversity

A search of the NatureMap database (DPaW, 2007–) identified 224 fauna species as previously recorded within the Study Area, of which 220 species are native and four are pest (introduced) species (Appendix C).

The Spring field survey recorded a total of 102 fauna species, consisting of 63 birds, 19 reptiles, 19 mammals and one amphibian within the Survey Area. Of these, seven are introduced (feral) species. The list of fauna species recorded during the survey is provided in Appendix E.

The fauna species recorded using the camera traps, Elliot traps and bat detector unit (Songmeter SM2 bat +) are listed in Appendix E.

2.8.6 Conservation significant fauna

Desktop searches of the EPBC Act PMST (DotE 2013d) and NatureMap (DPaW 2007-) databases revealed the potential presence of 18 fauna taxa protected under the EPBC Act and/or WC Act or listed by DPaW as priority within the Study Area (Appendix C). In addition to these species, five conservation significant fauna species not identified in the database searches were identified as potentially occurring within the Study Area as they are known to occur in the region. These species include the Bush Stone-curlew, Major Mitchell's Cockatoo, Grey Falcon, Western Spiny-tailed Skink and Brush-tailed Mulgara.

Likelihood of occurrence

A likelihood of occurrence assessment, which takes into account the field survey data, habitats present, known species distribution and previous records, was completed for all conservation significant fauna taxa identified in the desktop assessment and known to occur in the region.

The assessment concluded that five species are known to occur (discussed below), four species are likely to occur, two species could possibly occur and twelve species are unlikely to occur in the Suvey Area. A summary of the conservation significant fauna likelihood of occurrence assessment is shown in Table 12 and the full assessment is provided in Appendix E.

Table 12 Summary of conservation significant fauna - likelihood of occurrence assessment

Species	Common name	Status		Likelihood of occurrence
		State	Federal	
Birds				
Acanthiza iredalei iredalei	Slender-billed Thornbill (western)		V	Unlikely
Amytornis striatus subsp. *striatus*	Striated Grasswren (inland)	P4		Possible
Apus pacificus	Fork-tailed Swift	IA	Mi	Unlikely
Ardea modesta	Great Egret	IA	Mi	Unlikely
Ardeotis australis	Australian Bustard	P4		Present
Burhinus grallarius	Bush Stone-curlew	P4		Present
Cacatua leadbeateri	Major Mitchell's Cockatoo	S		Possible
Charadrius veredus	Oriental Plover	IA	Mi	Unlikely
Falco hypoleucos	Grey Falcon	T		Present
Falco peregrinus macropus	Peregrine Falcon	S		Likely
Leipoa ocellata	Malleefowl	T	V, Mi	Likely
Merops ornatus	Rainbow Bee-eater	IA	Mi	Present
Polytelis alexandrae	Princess Parrot	P4	V	Unlikely
Tyto novaehollandiae subsp. *novaehollandiae*	Masked Owl (southern subsp.)	P3		Unlikely
Mammals				
Dasycercus blythi	Brush-tailed Mulgara	P4		Present
Dasycercus cristicauda	Crest-tailed Mulgara	T	V	Unlikely
Macrotis lagotis	Bilby	T	V	Unlikely
Notoryctes caurinus	Northern Marsupial Mole	T	En	Unlikely
Rhinonicteris aurantia (Pilbara form)	Pilbara Leaf-nosed Bat	T	V	Unlikely
Sminthopsis longicaudata	Long-tailed Dunnart	P4		Likely
Reptiles				
Lerista eupoda	Good-legged Lerista skink	P1		Likely
Liopholis kintorei	Giant Desert Skink	T	V	Unlikely
Egernia stokesii badia	Western Spiny-tailed Skink	T	En	Unlikely

Targeted fauna assessment

Species recorded during field assessment

The field surveys conducted by GHD identified five conservation significant fauna species within the Survey Area, including:

- Grey Falcon (*Falco hypoleucos*) – Threatened under the WC Act
- Australian Bustard (*Ardeotis australis*) – Priority 4 listed by DPaW
- Bush Stone-curlew (*Burhinus grallarius*) – Priority 4 listed by DPaW
- Brush-tailed Mulgara (*Dasycercus blythi*) – Priority 4 listed by DPaW
- Rainbow Bee-eater (*Merops ornatus*) – Schedule 3 under the WC Act and Migratory under the EPBC Act

A brief description of each of these species and their associated habitat types is provided below.

Mulgara

The results of the desktop assessment indicate that the EPBC – listed Vulnerable Crest-tailed Mulgara (*Dasycercus cristicauda*) has been recorded within 50 km of the Survey Area. The closest of these includes three records from one location approximately 10 km south of the Goldfields Highway, and 31 km south-west of Wiluna in 2007 (*NatureMap* and DPaW data). Recent research regarding the taxonomic status and distribution of this species and the Brush-tailed Mulgara (*Dasycercus blythi*) by Woolley *et al*. (2013) has revealed that the Crest-tailed Mulgara has not been recorded in Western Australia since the Canning Stock Route Expedition in 1930-1. Woolley *et al*. (2013) stipulates that this may simply reflect a lack of targeted collecting activity in appropriate habitat, rather than the absence of the species. In addition to this, historic records of Crest-tailed Mulgara are restricted to the Northern Deserts of the Canning Stock Route, and are not known from the vicinity of the Survey Area.

By comparison, there are multiple records of the Brush-tailed Mulgara in close proximity to the Survey Area. Museum specimen records of the Brush-tailed Mulgara exist from the Canning Stock Route in 2002 when five individuals were caught (one a little north of Well 27 and two near Well 29) and in 2008 when one individual was caught (near Well 26) (Woolley *et al*. 2013). These locations are approximately 540 km north-east of the Survey Area and therefore may not be relevant to the current survey, however they do confirm that the species has been vouchered in Western Australia more recently than the Crest-tailed Mulgara. Further to this, there are numerous *NatureMap* records of the Brush-tailed Mulgara within proximity of the Survey Area.

Records of Brush-tailed Mulgara have previously been misidentified as Crest-tailed Mulgara (Woolley *et al*. 2013), and therefore it is likely that the three 2007 records of the species are the DPaW Priority 4-listed Brush-tailed Mulgara. However it is difficult to definitively confirm this, as these records were not verified by the Western Australian Museum. Woolley *et al*. (2013) also indicates that Crest-tailed Mulgara records are typically from sand dune habitats, whereas Brush-tailed Mulgara habitat is typically spinifex grasslands with medium to dense cover (Woolley 2005; Woolley *et al*. 2013). In addition the Brush-tailed Mulgara is closely associated with *Triodia* Sand Plains and swales between low dunes from south-western Queensland across the Simpson, Tanami, and Great Sandy Deserts of southern and central Northern Territory and central Western Australia, including parts of the Pilbara (Pavey *et al*. 2012).

These findings are consistent with the information presented at the recent DPaW Mulgara workshop on the 11th December 2013. The status of both species is currently under review by the DotE, and the Brush-tailed Mulgara is currently under consideration for listing under the EPBC Act (DSEWPaC 2012).

Field assessment – A number of Mulgara active and old burrows, prints and scats were recorded within spinifex grassland habitat in the Survey Area (Plate 19). It is likely that this evidence is of the Brush-tailed Mulgara, based on the literature discussed above and that these records came from spinifex grasslands. These survey records are shown in Figure 9.

Two camera traps were also positioned on active Mulgara burrows within spinifex grasslands (as shown in Plate 19), however no photos of Mulgara were captured during the field survey.

Plate 19 Camera trap set-up targeting active Mulgara burrow and Mulgara prints recorded in the Project Area.

Rainbow Bee-eater (*Merops ornatus*)

The Rainbow Bee-eater is listed under Schedule 3 of the WC Act (Migratory birds protected under an international agreement) and as Migratory under the EPBC Act. The Rainbow bee-eater occupies open forests and woodlands, shrublands, and in various cleared or semi-cleared habitats, including farmland and areas of human habitation throughout Australia. It also inhabits sand dune systems in coastal areas and at inland sites that are in close proximity to water (Morcombe, 2004). The species is a breeding resident in northern Australia, and a summer breeding migrant to southern Australia.

Field assessment – Rainbow Bee-eaters were observed in the Survey Area during the field survey. It is likely that the species is an occasional seasonal migrant to the Survey Area. No breeding of the species was recorded however suitable breeding habitat is present throughout the Survey Area in sandy soils. It should be noted that Rainbow Bee-eaters often take advantage of windrows of soil pushed up by graders and earth moving equipment along tracks, and may potentially use these areas for breeding.

Australian Bustard (*Ardeotis australis*)

The Australian Bustard is listed as Priority 4 by DPaW, and is therefore is classified as 'Rare, Near Threatened and other taxa in need of monitoring'. The Australian Bustard occurs across much of Australia, including across most of Western Australian, except in heavily wooded areas in the south. It occurs mainly in open country, such as grasslands, low heath or lightly wooded grassland (Morcombe, 2004). The Bustard is a nomadic bird which is known to migrate to suitable feeding areas dependent upon conditions.

Field assessment – Australian Bustard tracks were recorded within hummock grassland habitats in the Survey Area during the field survey (Figure 9). It is likely that the Bustard is a nomadic visitor to the Survey Area, and is likely to utilise all of the habitat types for foraging. Given the availability of suitable habitat in the local area and surrounding region, the proposed project is unlikely to have a significant impact on this species.

Bush Stone-curlew (*Burhinus grallarius*)

The Bush Stone-curlew as Priority 4 by DPaW and inhabits dry open woodlands, lightly timbered country, mallee and mulga; anywhere with groundcover of small sparse shrubs, grass or litter of twigs. The species avoids dense forest and closed canopy habitats (Morcombe 2004). In southern Australia, they persist most often where there is a well-structured litter layer and fallen timber debris. In general, habitat occurs in open woodlands with few, if any, shrubs, and short, sparse grasses of less than 15 cm in height, with scattered fallen timber, leaf litter and bare ground present.

Field assessment – One Bush Stone-curlew individual was recorded on camera trap 4, located at the dam on the north side of the highway (near SLK 741) during the field survey (Figure 9).

Grey Falcon (*Falco hypoleucos*)

The Grey Falcon inhabits lightly timbered country, especially stony plains and lightly timbered *Acacia* scrub, and generally uses standing dead trees as lookout posts. This species is considered scarce to rare and is usually found singularly or sometimes in pairs (Morcombe 2004).

Field assessment – One Grey Falcon individual was observed perching on a dead tree within *Acacia* shrubland during the field survey. This species has not previously been recorded within 50 km of the Survey Area, and therefore it is likely to occur only rarely in the region.

Species targeted but not recorded during field assessment

Targeted assessments were conducted during the field survey for the following species and the results are outlined below:

- Greater Bilby (*Macrotis lagotis*) - Threatened under the WC Act, Vulnerable under the EPBC Act
- Long-tailed Dunnart (*Sminthopsis longicaudata*) - Priority 4 listed by DPaW
- Malleefowl (*Leipoa ocellata*) - Threatened under the WC Act, Vulnerable under the EPBC Act
- Northern Marsupial Mole (*Notoryctes caurinus*) - Threatened under the WC Act, Endangered under the EPBC Act
- Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*) - Threatened under the WC Act, Vulnerable under the EPBC Act
- Great Desert Skink (*Liopholis kintorei*) - Threatened under the WC Act, Vulnerable under the EPBC Act
- Western Spiny-tailed Skink (*Egernia stokesii badia*) - Threatened under the WC Act, Endangered under the EPBC Act

Greater Bilby (*Macrotis lagotis*)

The Greater Bilby is listed as Vulnerable under the EPBC Act and is listed under Schedule 1 of the WC Act (Threatened).The Greater Bilby occupies three major vegetation types, including open tussock grassland on uplands and hills, mulga woodland/shrubland growing on ridges and rises, and hummock grassland in plains and alluvial areas. In the south of its range, the Greater Bilby lives on rises and ridges among sparse grasses. In Western Australia there are disjunct populations in the Gibson Desert, south-western Kimberley, inland areas of the Pilbara and northern Great Sandy Desert (Van Dyke and Strahan 2008).

Field assessment – During the field survey a total of 28 Bilby Search Areas (BSAs) were undertaken throughout the Survey Area in areas of suitable habitat. These BSAs are shown in Figure 9. No evidence of the Greater Bilby was recorded during these BSAs or throughout the field survey. There are historical *NatureMap* records of this species from the Wiluna area, however given the pastoral use of the region, and the degradation caused by cattle grazing it is unlikely that the Greater Bilby occurs within the Survey Area.

Long-tailed Dunnart (*Sminthopsis longicaudata*)

The Long-tailed Dunnart is listed as Priority 4 by DPaW and is known to occur from widely scattered localities in the arid zone where it inhabits rugged and rocky areas. These areas include scree slopes, boulder and stony plateaus, and adjacent stony plains with shrubs over spinifex grasslands (Van Dyck *et al.* 2013).

Field assessment – During the field survey, two quadrats of Elliot traps were set within rocky slope habitat at Mt Russell. No Long-tailed Dunnart individuals or evidence was recorded during the field survey.

Malleefowl (*Leipoa ocellata*)

The Malleefowl is classified as Vulnerable under the EPBC Act and is listed under Schedule 1 of the WC Act (Threatened). In Western Australia, the Malleefowl generally occurs in semi-arid areas, from Carnarvon to the south-west Nullarbor. The species occupies shrublands and low woodlands that are dominated by mallee vegetation, as well as native pine *Callitris* woodlands, *Acacia* shrublands, Broombush (*Melaleuca uncinata*) vegetation or coastal heathlands. They prefer vegetation with a dense understorey of shrubs and their breeding habitat is characterized by light soil and an abundant leaf litter, which is used in the construction of nesting mounds. The nest is a large mound of sand or soil and organic matter (Jones and Goth 2008; Morcombe, 2004).

Field assessment – Active searches within suitable *Acacia* shrubland were undertaken during the field survey, however no evidence (individuals, scratching, diggings, tracks or mounds) of the Malleefowl was recorded. The species has previously been recorded approximately halfway between Meekatharra and Wiluna in 2010. It is likely that the region is sparsely populated with the species as the Survey Area is located at the northern extent of its range. In addition there have also been multiple records (sightings, tracks and mounds) in 2006-7 of Malleefowl, approximately 20 km south of Goldfields Highway, just north of the Sandstone Wiluna Road.

Northern Marsupial Mole (*Notoryctes caurinus*)

The Northern Marsupial Mole is listed as Endangered under the EPBC Act and under Schedule 1 of the WC Act (Threatened). The Northern Marsupial Mole lives underground, primarily in sand dunes and sandy soils along river flats. It occasionally comes to the surface, apparently more frequently after rain (DotE 2013f). Underground signs of marsupial moles are usually found on well-vegetated dunes (where prey may be more abundant) and generally not in swales (flats between dunes). The vegetation in Northern Marsupial Mole habitat is generally *Acacia* spp., small shrubs and Desert Oak (*Allocasuarina decaisneana*) and often (but not always) associated with spinifex (*Triodia* spp.). Sandy river flats are also thought to be potential Northern Marsupial Mole habitat, as they are rich in food resources and may act as dispersal corridors. Underground signs of the species are generally found between 20—100 cm below the dune surface. Records of the Northern Marsupial Mole are predominantly known from the Little Sandy Desert, Great Sandy Desert and Gibson Desert regions of Western Australia (DotE 2013f).

Field assessment – Given the difficultly is surveying for this species, and that there is no proven or accepted survey technique to detect them, the field assessment for the Northern Marsupial Mole was restricted to targeted habitat searches. The only potential habitat for the species within the Survey Area is the small sand dune system located north of the highway (around SLK 732). Visual inspection of this dune habitat was undertaken looking for signs of use, however no evidence was recorded. Due to the isolated nature of this system, it is unlikely that the species occurs within this dune. Sand dune habitat is also rare in the surrounding area, and therefore suitable habitat for this species is limited surrounding the Survey Area.

Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*)

The Pilbara Leaf-nosed Bat is classified as Vulnerable under the EPBC Act and is listed under Schedule 1 of the WC Act (Threatened). The Pilbara Leaf-nosed Bat is restricted to the Pilbara region and field surveys suggest that it is divided into three discrete subpopulations (eastern Pilbara mines and granite, Hamersley Range, Upper Gascoyne). The Pilbara Leaf-nosed Bat is restricted to caves and mine adits (horizontal shafts) with stable, warm and humid microclimates because of its poor ability to thermoregulate and retain water. The roost is usually over pools of water in deeper mines, or deep within the mine or cave structure in an area that maintains elevated temperature and humidity. Thus, the roosting site is often at depth in mines; in small crevices within caves, usually those ascending between sedimentary rock layers; and with associated groundwater seeps.

Field assessment – A Songmeter SM2 bat + bat detector unit was deployed at six locations across the Survey Area (as shown in Figure 9), for one night each. The Pilbara Leaf-nosed Bat was not recorded using this detector, nor was any suitable habitat for the species identified within the Survey Area. The Pilbara Leaf-nosed Bat has not been recorded in the Mid-West region, and the closest record of the species is located 250 km north of the Survey Area in 1999.

Great Desert Skink (*Liopholis kintorei*)

The Great Desert Skink is classified as Vulnerable under the EPBC Act and is listed under Schedule 1 of the WC Act (Threatened). The Great Desert Skink generally occurs on red sandplains and sand ridges, and in Western Australia it is typically found at sites dominated by *Triodia basedowii* and *Triodia schinzii* with some *Eremophila leucophylla* shrubs. This species appears to prefer a mosaic landscape of different aged vegetation and inhabit sites that have been burnt in the previous three to fifteen years.

Field assessment – There was no suitable habitat for the Great Desert Skink identified during the field survey within the Survey Area and no evidence of the species was recorded. The nearest record of the species is located 100 km south-east of Wiluna from 1964.

Western Spiny-tailed Skink (*Egernia stokesii badia*)

The Western Spiny-tailed Skink is listed as Endangered under the EPBC Act and under Schedule 1 of the WC Act (Threatened). The Western Spiny-tailed Skink occurs in open eucalypt woodlands and Acacia-dominated shrublands in semi-arid to arid areas of south-western Western Australia. The 'black form' populations of this species occur in granite outcrops and lateritic breakaways in the Cue-Yalgoo-Mt Magnet region. Individuals of the 'black form' live on granite outcrops and ironstone breakaways and shelters in horizontal crevices and under boulders (DotE 2013f).

Field assessment – There is very limited suitable habitat for the Western Spiny-tailed Skink within the Survey Area, and no evidence of this species was recorded during active searches of rocky habitats.

2.8.7 Introduced fauna

Seven introduced species were recorded during the field assessment, including European Rabbits (*Oryctolagus cuniculus*), domestic cattle (*Bos taurus*), feral cats (*Felis catus*), feral dogs (*Canis lupus*), goats (*Capra hircus*), camels (*Camelus dromedarius*) and the House Mouse (*Mus musculus*).

Evidence of feral cats was recorded throughout the Survey Area during the field survey and one cat was recorded on one of the motion sensor camera traps (Camera 6). Feral dogs are also known to occur in the region, and together with feral cats, both of these predatory species are likely to have a significant impact on the native fauna occurring within the area.

Domestic cattle were also present, with evidence of this species throughout the majority of the Survey Area. Domestic cattle disturbance represents one of the major disturbances to the Survey Area, particularly in areas where they congregate such as well-marked cattle tracks and around water sources.

650,000 655,000 660,000 665,000

7,060,000

7,055,000

Fauna Legend

Conservation Significant Fauna (GHD)

- Active Mulgara burrow
- Mulgara prints
- Mulgara scat
- Old Mulgara burrow
- Australian Bustard prints
- Old Malleefowl mound

Conservation Significant Fauna (DPaW)

(Type, Conservation Code)

- MAMMAL, 4

Survey Locations

- Bat Detection Sites
- Elliot Trap Lines
- Camera Trap Locations
- Elliot Trap Lines
- Bilby Search Areas

Fauna Habitat Type

- Acacia shrubland over hummock grasses
- Acacia shrubland over tussock grasses
- Chenopod shrubland
- Cleared/Highly disturbed
- Eucalyptus/Corymbia woodland
- Mixed shrubland
- Previously cleared/regrowth
- Rocky outcrops, breakaways and BIF hills
- Tussock grassland

Great Northern Hwy
Main St
High St
Hill St
Dardo St
Railway St
Campbell Rd
Mecleary St
Meekatharra-Sandstone Rd
Murchison Downs Rd
Goldfields Hwy
793 792 791 790 789 788 787 786 785 784 783 782 781 780 779 778 777 776 775
Camera 1

1:50,000 (at A3)

0 0.5 1 1.5 2 2.5

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map

1 MEEKATHARRA 2 3 4 5 6 7 8 9 WILUNA 10 11

Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

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Revision	0
Date	17 Sep 2014

Fauna habitat, conservation significant fauna locations and survey locations

Sheet 1 of 11

Figure 9

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Data source: GA: Mainlands, Roads, Localities - 2007; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; MRWA: SLK - 20131219; DPaW: Conservation Significant Fauna; GHD: Camera Trap Locations - 20140618, Additional Conservation Significant Fauna - 20140612, Study Area, Impact Area - 20140617. Created by: bflorczak

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670,000 675,000 680,000 685,000

7,065,000

7,060,000

Fauna Legend

Conservation Significant Fauna (GHD)

- Active Mulgara burrow
- Mulgara prints
- Mulgara scat
- Old Mulgara burrow
- Australian Bustard prints
- Old Malleefowl mound

Survey Locations

- Bat Detection Sites
- Elliot Trap Lines
- Camera Trap Locations
- Elliot Trap Lines
- Bilby Search Areas

Fauna Habitat Type

- Acacia shrubland over hummock grasses
- Acacia shrubland over tussock grasses
- Chenopod shrubland
- Cleared/Highly disturbed
- Eucalyptus/Corymbia woodland
- Mixed shrubland
- Previously cleared/regrowth
- Rocky outcrops, breakaways and BIF hills
- Tussock grassland

753 754 755 756 757 758 759 760 761 762 763 765 766 767 768 769 770 771 772 773 774

Goldfields Hwy

Camera 2

1:50,000 (at A3)

0 0.5 1 1.5 2 2.5

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map

1 MEEKATHARRA 2 3 4 5 6 7 8 9 WILUNA 10 11

Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Job Number	61-30097
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Fauna habitat, conservation significant fauna locations and survey locations

Sheet 2 of 11

Figure 9

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Data source: GA: Mainlands, Roads, Localities - 2007; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; MRWA: SLK - 20131219; DPaW: Conservation Significant Fauna; GHD: Camera Trap Locations - 20140618, Additional Conservation Significant Fauna - 20140612, Study Area, Impact Area - 20140617. Created by: bflorczak

690,000 695,000 700,000 705,000

7,075,000

7,070,000

Fauna Legend

Conservation Significant Fauna (GHD)

- Active Mulgara burrow
- Mulgara prints
- Mulgara scat
- Old Mulgara burrow
- Australian Bustard prints
- Old Malleefowl mound

Survey Locations

- Bat Detection Sites
- Elliot Trap Lines
- Camera Trap Locations
- Elliot Trap Lines
- Bilby Search Areas

Fauna Habitat Type

- Acacia shrubland over hummock grasses
- Acacia shrubland over tussock grasses
- Chenopod shrubland
- Cleared/Highly disturbed
- Eucalyptus/Corymbia woodland
- Mixed shrubland
- Previously cleared/regrowth
- Rocky outcrops, breakaways and BIF hills
- Tussock grassland

Camera 9
Camera 8
Camera 6
Camera 7
Camera 5
Camera 4
Camera 3
731
732
734
735
736
737
738
739
740
741
742
744
745
746
747
748
749
750
751
752
Goldfields Hwy

1:50,000 (at A3)

0 0.5 1 1.5 2 2.5

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map

1 MEEKATHARRA 2 3 4 5 6 7 8 9 WILUNA 10 11

Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Job Number	61-30097
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Fauna habitat, conservation significant fauna locations and survey locations

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Figure 9

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Data source: GA: Mainlands, Roads, Localities - 2007; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; MRWA: SLK - 20131219; DPaW: Conservation Significant Fauna; GHD: Camera Trap Locations - 20140618, Additional Conservation Significant Fauna - 20140612, Study Area, Impact Area - 20140617. Created by: bflorczak

710,000 715,000 720,000 725,000

7,080,000

7,075,000

7,070,000

Fauna Legend

Conservation Significant Fauna (GHD)
- Active Mulgara burrow
- Mulgara prints
- Mulgara scat
- Old Mulgara burrow
- Australian Bustard prints
- Old Malleefowl mound

Survey Locations
- Bat Detection Sites
- Elliot Trap Lines
- Camera Trap Locations
- Elliot Trap Lines
- Bilby Search Areas

Fauna Habitat Type
- Acacia shrubland over hummock grasses
- Acacia shrubland over tussock grasses
- Chenopod shrubland
- Cleared/Highly disturbed
- Eucalyptus/Corymbia woodland
- Mixed shrubland
- Previously cleared/regrowth
- Rocky outcrops, breakaways and BIF hills
- Tussock grassland

Camera 10

730 729 728 727 726 725 724 723 722 721 720 719 718 717 716 715 714 713 712 711

Goldfields Hwy

1:50,000 (at A3)

0 0.5 1 1.5 2 2.5

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND
- SLK Marker
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map

1 MEEKATHARRA 2 3 4 5 6 7 8 9 WILUNA 10 11

Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Job Number	61-30097
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Fauna habitat, conservation significant fauna locations and survey locations

Sheet 4 of 11

Figure 9

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Data source: GA: Mainlands, Roads, Localities - 2007; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; MRWA: SLK - 20131219; DPaW: Conservation Significant Fauna; GHD: Camera Trap Locations - 20140618, Additional Conservation Significant Fauna - 20140612, Study Area, Impact Area - 20140617. Created by: bflorczak

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730,000 735,000 740,000 745,000

7,075,000 7,070,000

Elliot 1
Camera 12
Elliot 4
Elliot 3
Camera 15
Goldfields Hwy
Camera 13
Camera 14
Elliot 2
Camera 16
Diamond

710 709 708 Camera 11 706 705 704 703 Goldfields Hwy 701 700 699 697 696 695 694 693 692 691

Elliot 1
Elliot 3
Camera 15
Elliot 4
Camera 12
Camera 14
Camera 13
Elliot 2
Camera 16

Fauna Legend

Conservation Significant Fauna (GHD)
- Active Mulgara burrow
- Mulgara prints
- Mulgara scat
- Old Mulgara burrow
- Australian Bustard prints
- Old Malleefowl mound

Conservation Significant Fauna (DPaW)
(Type, Conservation Code)
- BIRD, T

Survey Locations
- Bat Detection Sites
- Elliot Trap Lines
- Camera Trap Locations
- Elliot Trap Lines
- Bilby Search Areas

Fauna Habitat Type
- Acacia shrubland over hummock grasses
- Acacia shrubland over tussock grasses
- Chenopod shrubland
- Cleared/Highly disturbed
- Eucalyptus/Corymbia woodland
- Mixed shrubland
- Previously cleared/regrowth
- Rocky outcrops, breakaways and BIF hills
- Tussock grassland

730,000 735,000 740,000 745,000

1:50,000 (at A3)

0 0.5 1 1.5 2 2.5

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND
- SLK Marker
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map
1 MEEKATHARRA 2 3 4 5 6 7 8 9 WILUNA 10 11

Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

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Fauna habitat, conservation significant fauna locations and survey locations

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Figure 9

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Data source: GA: Mainlands, Roads, Localities - 2007; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; MRWA: SLK - 20131219; DPaW: Conservation Significant Fauna; GHD: Camera Trap Locations - 20140618, Additional Conservation Significant Fauna - 20140612, Study Area, Impact Area - 20140617. Created by: bflorczak

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750,000 755,000 760,000 765,000

7,075,000 7,070,000 7,065,000

Fauna Legend

Conservation Significant Fauna (GHD)

- Active Mulgara burrow
- Mulgara prints
- Mulgara scat
- Old Mulgara burrow
- Australian Bustard prints
- Old Malleefowl mound

Conservation Significant Fauna (DPaW)

(Type, Conservation Code)

- BIRD, S

Survey Locations

- Bat Detection Sites
- Elliot Trap Lines
- Camera Trap Locations
- Elliot Trap Lines
- Bilby Search Areas

Fauna Habitat Type

- Acacia shrubland over hummock grasses
- Acacia shrubland over tussock grasses
- Chenopod shrubland
- Cleared/Highly disturbed
- Eucalyptus/Corymbia woodland
- Mixed shrubland
- Previously cleared/regrowth
- Rocky outcrops, breakaways and BIF hills
- Tussock grassland

690 689 688 687 686 685 684 683 682 681 Goldfields Hwy 679 678 677 676 675 674 673 672 671

Camera 17 Camera 18

1:50,000 (at A3)

0 0.5 1 1.5 2 2.5

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map

1 MEEKATHARRA 2 3 4 5 6 7 8 9 WILUNA 10 11

Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

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Fauna habitat, conservation significant fauna locations and survey locations

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Figure 9

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Data source: GA: Mainlands, Roads, Localities - 2007; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; MRWA: SLK - 20131219; DPaW: Conservation Significant Fauna; GHD: Camera Trap Locations - 20140618, Additional Conservation Significant Fauna - 20140612, Study Area, Impact Area - 20140617. Created by: bflorczak

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770,000 775,000 780,000 785,000

7,070,000

Paroo Rd

Coldfields Hwy

Elliot 6
Camera 20
Elliot 5

670 669 Camera 19 668 667 666 665 664 663 662 661 659 658 657 656 655 654 653 652 651 650

Elliot 6
Elliot 5
Camera 20

7,065,000

770,000 775,000 780,000 785,000

Fauna Legend

Conservation Significant Fauna (GHD)
- Active Mulgara burrow
- Mulgara prints
- Mulgara scat
- Old Mulgara burrow
- Australian Bustard prints
- Old Malleefowl mound

Survey Locations
- Bat Detection Sites
- Elliot Trap Lines
- Camera Trap Locations
- Elliot Trap Lines
- Bilby Search Areas

Fauna Habitat Type
- Acacia shrubland over hummock grasses
- Acacia shrubland over tussock grasses
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- Cleared/Highly disturbed
- Eucalyptus/Corymbia woodland
- Mixed shrubland
- Previously cleared/regrowth
- Rocky outcrops, breakaways and BIF hills
- Tussock grassland

1:50,000 (at A3)

0 0.5 1 1.5 2 2.5

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND
- SLK Marker
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map

1 MEEKATHARRA 2 3 4 5 6 7 8 9 WILUNA 10 11

Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

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Fauna habitat, conservation significant fauna locations and survey locations

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Figure 9

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Data source: GA: Mainlands, Roads, Localities - 2007; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; MRWA: SLK - 20131219; DPaW: Conservation Significant Fauna; GHD: Camera Trap Locations - 20140618, Additional Conservation Significant Fauna - 20140612, Study Area, Impact Area - 20140617. Created by: bflorczak

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790,000 795,000 800,000 805,000

7,065,000 7,060,000 7,055,000

Fauna Legend

Conservation Significant Fauna (GHD)
- Active Mulgara burrow
- Mulgara prints
- Mulgara scat
- Old Mulgara burrow
- Australian Bustard prints
- Old Malleefowl mound

Survey Locations
- Bat Detection Sites
- Elliot Trap Lines
- Camera Trap Locations
- Elliot Trap Lines
- Bilby Search Areas

Fauna Habitat Type
- Acacia shrubland over hummock grasses
- Acacia shrubland over tussock grasses
- Chenopod shrubland
- Cleared/Highly disturbed
- Eucalyptus/Corymbia woodland
- Mixed shrubland
- Previously cleared/regrowth
- Rocky outcrops, breakaways and BIF hills
- Tussock grassland

649 648 647 646 Camera 21 645 644 643 642 641 640 639 638 637 636 Camera 22 635 Goldfields Hwy 633 632 631 630 629 628 627 Camera 23 Camera 24

1:50,000 (at A3)

0 0.5 1 1.5 2 2.5

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND
- SLK Marker
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map

1 MEEKATHARRA 2 3 4 5 6 7 8 9 WILUNA 10 11

Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Job Number	61-30097
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Date	17 Sep 2014

Fauna habitat, conservation significant fauna locations and survey locations

Sheet 8 of 11

Figure 9

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Data source: GA: Mainlands, Roads, Localities - 2007; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; MRWA: SLK - 20131219; DPaW: Conservation Significant Fauna; GHD: Camera Trap Locations - 20140618, Additional Conservation Significant Fauna - 20140612, Study Area, Impact Area - 20140617. Created by: bflorczak

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Fauna Legend

Conservation Significant Fauna (GHD)
- Active Mulgara burrow
- Mulgara prints
- Mulgara scat
- Old Mulgara burrow
- Australian Bustard prints
- Old Malleefowl mound

Conservation Significant Fauna (DPaW)
(Type, Conservation Code)
- BIRD, 4
- BIRD, IA
- MAMMAL, 4
- MAMMAL, T

Survey Locations
- Bat Detection Sites
- Elliot Trap Lines
- Camera Trap Locations
- Elliot Trap Lines
- Bilby Search Areas

Fauna Habitat Type
- Acacia shrubland over hummock grasses
- Acacia shrubland over tussock grasses
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- Cleared/Highly disturbed
- Eucalyptus/Corymbia woodland
- Mixed shrubland
- Previously cleared/regrowth
- Rocky outcrops, breakaways and BIF hills
- Tussock grassland

810,000 815,000 820,000 825,000

7,060,000 7,055,000 7,050,000

626 625 624 623 622 621 618 617 616 615 614 613 612 611 610 609 607

Goldfields Hwy

Wiluna North Rd

Wongawol Rd

Village Rd

Forrest St

Scotia St

Lennon St

Welton St

1:50,000 (at A3)

0 0.5 1 1.5 2 2.5

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND
- SLK Marker
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

Locality Map

1 MEEKATHARRA 2 3 4 5 6 7 8 9 WILUNA 10 11

Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Job Number	61-30097
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Date	17 Sep 2014

Fauna habitat, conservation significant fauna locations and survey locations

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Figure 9

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Data source: GA: Mainlands, Roads, Localities - 2007; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; MRWA: SLK - 20131219; DPaW: Conservation Significant Fauna; GHD: Camera Trap Locations - 20140618, Additional Conservation Significant Fauna - 20140612, Study Area, Impact Area - 20140617. Created by: bflorczak

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750,000 755,000 760,000 765,000

7,060,000

7,055,000

Fauna Legend

Conservation Significant Fauna (GHD)

- Active Mulgara burrow
- Mulgara prints
- Mulgara scat
- Old Mulgara burrow
- Australian Bustard prints
- Old Malleefowl mound

Survey Locations

- Bat Detection Sites
- Elliot Trap Lines
- Camera Trap Locations
- Elliot Trap Lines
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Fauna Habitat Type

- Acacia shrubland over hummock grasses
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- Cleared/Highly disturbed
- Eucalyptus/Corymbia woodland
- Mixed shrubland
- Previously cleared/regrowth
- Rocky outcrops, breakaways and BIF hills
- Tussock grassland

1:50,000 (at A3)

0 0.5 1 1.5 2 2.5

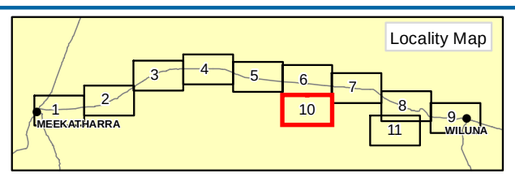
Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area



Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Job Number	61-30097
Revision	0
Date	17 Sep 2014

Fauna habitat, conservation significant fauna locations and survey locations

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Figure 9

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785,000 790,000 795,000 800,000

7,055,000

7,050,000

7,045,000

Fauna Legend

Conservation Significant Fauna (GHD)

- Active Mulgara burrow
- Mulgara prints
- Mulgara scat
- Old Mulgara burrow
- Australian Bustard prints
- Old Malleefowl mound

Conservation Significant Fauna (DPaW)
(Type, Conservation Code)

- MAMMAL, T

Survey Locations

- Bat Detection Sites
- Elliot Trap Lines
- Camera Trap Locations
- Elliot Trap Lines
- Bilby Search Areas

Fauna Habitat Type

- Acacia shrubland over hummock grasses
- Acacia shrubland over tussock grasses
- Chenopod shrubland
- Cleared/Highly disturbed
- Eucalyptus/Corymbia woodland
- Mixed shrubland
- Previously cleared/regrowth
- Rocky outcrops, breakaways and BIF hills
- Tussock grassland

785,000 790,000 795,000 800,000

1:50,000 (at A3)

0 0.5 1 1.5 2 2.5

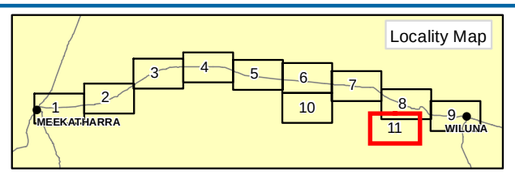
Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- SLK Marker
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area



Main Roads Western Australia
Goldfields Highway Wiluna to Meekatharra
EIA & EMP

Job Number	61-30097
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Fauna habitat, conservation significant fauna locations and survey locations

Sheet 11 of 11

Figure 9

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Data source: GA: Mainlands, Roads, Localities - 2007; Landgate: Roads - 20140611, Mooloogool 2006 Mosaic - 20131121, Gabanintha 2006 Mosaic - 20131121, Mount Bartle 2006 Mosaic - 20131121, Yaganoo 2006 Mosaic - 20131121; MRWA: SLK - 20131219; DPaW: Conservation Significant Fauna; GHD: Camera Trap Locations - 20140618, Additional Conservation Significant Fauna - 20140612, Study Area, Impact Area - 20140617. Created by: bflorczak

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2.9 Land vesting and existing use

2.9.1 Pastoral lease

The Survey Area traverses a number of different land tenures including leasehold for pastoralism, leasehold for conservation and road reserve. The Survey Area intersects six pastoral leases, including Millbillillie, Lake Way, Paroo, Mooloogool, Killara and Sherwood. The dominant landuse on these leases is livestock (cattle) grazing of native pastures.

In a number of areas the existing road is not within the road reserve, this is assumed to be related to errors in mapping accuracy in the past.

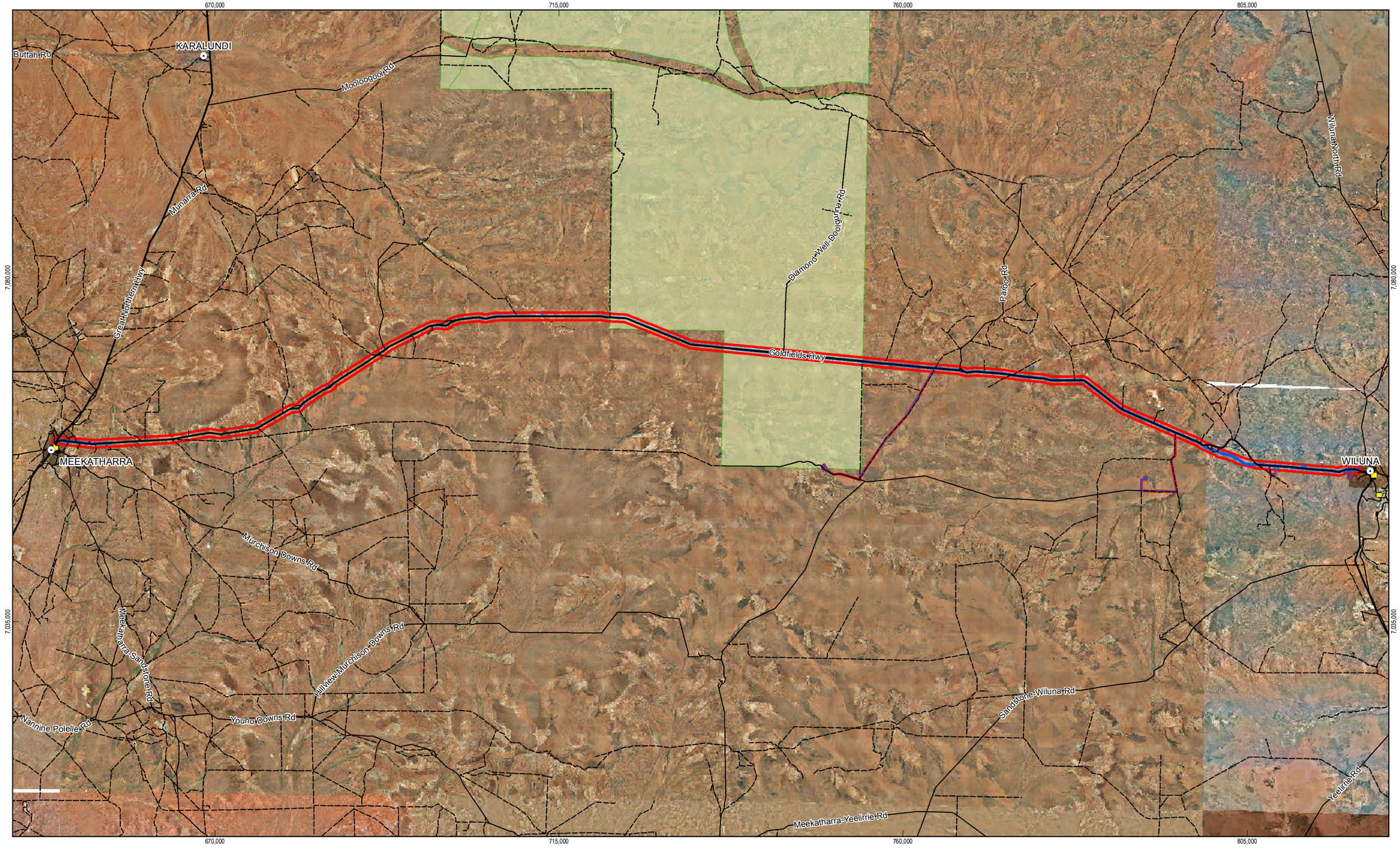
2.9.2 Conservation areas

The Survey Area does not intersect any conservation reserves. However, Mooloogool pastoral station, which was relinquished to DPaW and destocked in the early 2000's is a proposed conservation area. Mooloogool Station holds no reservation status at this time.

2.10 Environmentally Sensitive Areas

A search of the Department of Environment and Regulation (DER) (was DEC) Native Vegetation Viewer (DEC 2013c) did not identify any ESAs within the Survey Area.

The Native Vegetation Map Viewer (DEC 2013c) indicates that the Survey Area intersects three areas that are listed as Schedule 1 areas. Under Schedule 1 of the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* low impact mineral and petroleum activities may be exempt from requiring a clearing permit in certain areas. The Schedule 1 areas identified in the Native Vegetation Map Viewer area areas where the regulations do not apply. Two of these areas are located within Meekatharra and Wiluna and one occurs in the central part of the Survey Area (part of Lot 143, Shire of Meekatharra).



1: 450,000 (at A3)

0 5 10 15 20 25

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

LEGEND

- Localities
- Highway
- Minor Road
- Track
- Impact Area
- Survey Area

DPaW Managed Land & Waters (DPaW 2014)

- Former Leasehold

European Heritage (State Heritage Office 2013)

- Permanent Heritage Site

Main Roads Western Australia
EIA and EMP for
Goldfields Highway Project

Job Number	61-30097
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Date	16 Sep 2014

Landuse and Heritage

Figure 10

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Data source: GA: Localities; SHO: European Heritage 2013; DPaW: Managed Land & Waters, 2014; Landgate: Virtual Mosaic, Roads - 20140611; GHD: Study Area, Impact Area - 20140617. Created by: ES

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2.11 Contamination

A search of the DER Contaminated Sites database (DPaW 2013a) indicated that no recorded contaminated sites or potentially contaminated sites occur within the Survey Area.

There are two contaminated sites located in the Meekatharra town site and one in the Wiluna town site; however these sites occur outside the Survey Area. The land use of the Survey Area has predominantly been low intensity grazing, therefore the likelihood of contamination for this land use is low.

2.12 Visual Amenity

There is limited topographic relief in the Survey Area which predominantly consists of low undulating plains and low rocky hills and outcrops. The existing amenity of the Study Area comprises of pastoral lands and landscape features such as low outcrops. There are limited residences within the Survey Area that would be affected by the visual amenity of the road. However, residences occur within 300 to 400 m of the road within the town of Meekatharra and at the homestead of Mt Russell Waters, which was recorded during the field survey at SLK 661. The visual amenity of the Survey Area would be likely appreciated by road users, which includes tourist traffic.

2.13 Air quality and dust

There is no publicly available air quality monitoring data for the Study Area. No air quality monitoring has been carried out as part of this assessment. There is likely to be minimal pollution (other than dust) due to the regional nature (dominated by pastoral use) and low traffic volumes.

Dust is likely to be measureable in the area, which is typical of regional areas.

2.14 Noise and vibration

Noise monitoring has not been undertaken and therefore there is no quantitative information available with respect to the existing noise environment. The regional aspect of the Study Area and low traffic volumes suggest that noise and vibration in the area would be minimal.

2.15 Heritage (non-indigenous)

2.15.1 World heritage

A search of the EPBC Act PSMT database (DotE 2013d) did not identify any World Heritage Properties within the Survey Area.

2.15.2 National heritage

The National Heritage List is a list of natural, historic and Indigenous places that are of outstanding national heritage value to the Australian nation. No national heritage-listed places were identified within the Survey Area.

2.15.3 Commonwealth heritage

The Commonwealth Heritage List is a list of natural, indigenous and historic heritage places owned or controlled by the Australian Government. No Commonwealth heritage-listed places were identified within the Survey Area.

2.15.4 European heritage

A search of the Australian Heritage (DotE 2013e) and the InHerit (GoWA 2013a) databases did not identify any heritage sites within the Survey Area.

There are five heritage sites in close proximity to the Survey Area (Table 13).

Table 13 Heritage sites in close proximity to the Survey Area

Site name	Place ID/no.	Database	Location	Distance from Survey Area
Canning Stock Route (former)	Place ID 18153	Australian Heritage - Indicative Place	Eight kilometre wide strip of land running from Wiluna 1,867 km north-east to Billiluna Station near Lake Gregory, 169 km south-east of Halls Creek	One kilometre north east of the eastern end of the Survey Area
Old Courthouse	Place ID 10829	Australian Heritage - Registered Place	Darlot Street, Meekatharra	350 m south of the Survey Area
Wiluna District Hospital Group	Place no 3635	InHerit - State Registered Place	Scotia Street, Wiluna	1.7 km east of the eastern end of the Survey Area
Mine Manager's House	Place no. 5507	InHerit - State Registered Place	2 km south east of Wiluna	3.7 km south east of the eastern end of the Survey Area
Masonic Lodge	Place no. 1530	InHerit - State Registered Place	Corner of Darlot and Savage Streets Meekatharra	360 m south of the Survey Area
Presbyterian Church	Place no. 1529	InHerit - State Registered Place	Darlot Street, Meekatharra	350 m south of the Survey Area

3. Potential Environmental Impacts

3.1 Geology, soils & topography

3.1.1 Acid Sulfate Soils

As there is a very low risk of ASS occurring within the impact area and the Project will not require excavations below the water-table there is a very low likelihood of impact on ASS. However, disturbance of natural ground within seasonally inundated areas and salt pans will require further assessment prior to commencing construction.

3.2 Land systems

The 13 land systems described by Mabbutt *et al*. (1963) that occur within the survey area have been assessed to determine the percentage of each land system that will be impacted by clearing of the Impact Area (Table 14). This shows that the Impact Area contains less than 0.07% of each the land systems. Therefore the expected impact on these land systems is minor.

Table 14 Percentage of land systems within the Survey Area and Impact Area

Land system	Total extent (ha)	Area (ha) within Survey Area	Area (ha) within Impact Area	Maximum percentage (%) of land system within the Impact Area
RGEWIL Wiluna Land System	261,358	452.97	13.67	0.005
RGEBEL Belele Land System	582,013	859	24.35	0.004
RGEGAB Gabanintha Land System	252,929	140.29	2.45	0.001
RGESHE Sherwood Land System	1,587,328	1,619.24	38.21	0.002
RGEYNG Yanganoo Land System	2,032,067	3,263.85	73.43	0.004
RGEBLM Bullimore Land System	4,419,747	729.45	34.2	0.0008
RGETRN Trennaman Land System	90,729	262.44	8.09	0.009
RGEGLY Glengarry Land System	220,090	1,627.36	75.96	0.03
RGECUN Cunyu Land System	330,976	2,743.76	85.6	0.026
RFEDUL Dural Land System	219,048	3,630.25	105	0.048
RGEDIA Diamond Land System	46,083	1,710.32	31.79	0.069
RGEJUN Jundee Land System	661,594	531.05	17.81	0.003
RGEVIO Violet Land System	583,687	426.73	23.99	0.004

Mabbutt *et al*. (1963)

3.3 Hydrology

The Project will involve activities that have the potential to impact surface water hydrology, including:

- Changes to land topography that modifies overland flow patterns
- Development of infrastructure that modifies overland flow patterns
- Interruption to existing surface water flow patterns
- Increased erosion and sedimentation
- Contamination of surface water by chemicals and hydrocarbons

3.3.1 Groundwater

Groundwater extraction may be required during construction. Where possible Main Roads will use existing bores and licences; however additional water licences may be required. Impacts on the PEC associated with groundwater may occur, depending on where the groundwater extraction will occur (impacts discussed in Section 3.5.3).

3.3.2 Surfacewater

Drainage impacts during construction works and operation are issues in respect to maintaining existing surface water flows. As the majority of drainage on the surveyed areas is intermittent and poorly defined the risks of significant impacts to surface water flows are low. The following impacts are likely to occur:

- There are minor risks of erosion in the pit areas
- Pit excavation has the potential to create temporary pools following rainfall

The Project requires the crossing of several water courses with the subsequent construction of bridges and culverts. The bridges and culverts will be designed to have no effect on the existing natural flows, thus minimising impacts on the watercourses.

Potential impacts to watercourses may occur during construction through clearing and earthworks. The construction of the bridges will result in the clearing of the riparian vegetation along a small section of the creeks in the construction zone. Construction is likely to occur during the dry season, thus minimising potential impacts on flows through watercourses during the construction works. Impacts will be minimised by appropriate management measures that should be implemented through the EMP.

Some localised erosion may occur during significant rainfall events. This is considered to be a greater issue during the construction phase following clearing. During operation erosion may be mitigated through measures such as rock protection placement and rehabilitation of cleared areas. Where the land is overlain by a mantle of stones the removal of these due to earthworks may lead to increased risk of erosion.

To minimise potential issues associated with drainage line erosion, rock protection or other soil protection controls should be implemented at bridges and culverts. With the implementation of these measures, the potential for erosion to occur is minor.

Water quality impacts may occur from water with changed pH, hydrocarbon pollution or mobilised dissolved metals as a result of the Project. This impact can be reduced through pollution control measures implemented during and after construction and within the operational EMP. Impacts as a result of possible changes to water quality are therefore expected to be minor.

3.3.3 Wetlands

No wetlands were recorded within or adjacent to the Impact Area and there are not expected to be any impacts on wetlands from this Project.

3.4 Regional biogeography

Clearing of the Impact Area will result in clearing of less than 0.002 % of each IBRA sub-region, as detailed in Table 15, and impacts at the IBRA region level are expected to be insignificant.

Table 15 Percentage of IBRA sub-region within Impact Area

IBRA sub-region	Total extent (ha)	Area (ha) within Survey Area	Area (ha) within Impact Area	% of total extent within Impact Area (regional impact)
Western Murchison	6,985,502.83	1,239.7	35.11	0.0005
Eastern Murchison	21,135,083.93	16,757.1	499.43	0.002

3.5 Vegetation and flora

The Project will create an Impact Area of 533.74 ha including clearing of approximately 519.24 ha of native vegetation, in Condition 4 or better.

The removal of vegetation has a number of potential impacts, including:

- Reduction in vegetation association extents
- Clearing of DPaW priority listed flora species
- Loss of fauna habitat
- Instability and increased erosion
- Increased runoff

3.5.1 Vegetation extents

The local and regional impacts on the loss of vegetation associations have been assessed using the remaining extents of the Beard (1974) vegetation associations calculated by the Department of Environment and Conservation (latest update 2012 –GOWA 2013b).

As indicated in Table 16, clearing of the Impact Area would result in clearing of less than 0.4% of the remaining extent of Beard's (1974) vegetation association at all levels. The clearing required for the Project is therefore unlikely to have a significant impact on the regional vegetation extents.

Table 16 Vegetation associations and extent (Beard 1974) within the Impact Area

Vegetation association	Scale	Pre-European Extent (ha)	Current Extent (ha)	Remaining (%)	Vegetation association within Impact Area (ha)	% of current extent within Impact Area
IBRA Region Murchison		28,120,586.77	28,044,823.42	99.73		
11	State	31,723	31,698	99.92	11.14	0.04
	Bioregion - Murchison	9,178	9,153	99.73		0.12
	Sub-region – Eastern Murchison	8,524	8,499	99.70		0.13
	LGA – Shire of Wiluna	7,037	7,012	99.64		0.16
18	State	19,892,305	198,437,27	99.76	219.14	0.001
	Bioregion - Murchison	12,403,172	12,363,252	99.68		0.002
	Sub-region –Western Murchison	2,133,276	2,128,414	99.77		0.01
	Sub-region – Eastern Murchison	10,269,896	10,234,838	99.96		0.002
	LGA – Shire of Wiluna	2,039,881	2,030,407	99.54		0.011
	LGA – Shire of Meekatharra	3,118,037	3,111,401	99.79		0.007
39	State	6,613,569	6,602,580	99.83	7.21	0.0001
	Bioregion - Murchison	1,148,400	1,138,065	99.10		0.0006
	Sub-region – Western Murchison	437,071	436,130	99.78		0.002
	LGA - Shire of Meekatharra	1,367,519	1,365,794	99.87		0.0005
29	State	7,903,991	7,900,200	99.95	227.85	0.003
	Bioregion - Murchison	2,956,382	2,955,695	99.98		0.008
	Sub-region – Western Murchison	2,160,147	2,159,669	99.98		0.01
	Sub-region – Eastern Murchison	796,235	796,026	99.97		0.03
	LGA – Shire of Wiluna	2,027,699	2,027,505	99.99		0.011
	LGA – Shire of Meekatharra	2,854,683	2,851,596	99.89		0.008
107	State	2,815,387	2,813,996	99.95	43.8	0.00003
	Bioregion - Murchison	2,792,383	2,790,992	99.95		0.002
	Sub-region – Eastern Murchison	2,785,303	2,783,912	99.95		0.002
	LGA – Shire of Meekatharra	287,359	287,359	100		0.02

Vegetation association	Scale	Pre-European Extent (ha)	Current Extent (ha)	Remaining (%)	Vegetation association within Impact Area (ha)	% of current extent within Impact Area
202	State	448,529	448,343	99.96	1.19	0.0003
	Bioregion - Murchison	339,742	339,641	99.97		0.0004
	Sub-region –Western Murchison	61,127	61,115	99.97		0.002
	Sub-region – Eastern Murchison	278,615	278,525	99.98		0.0004
	LGA – Shire of Wiluna	48,553	48,540	99.97		0.002
204	State	199,475	198,735	99.63	13.56	0.007
	Bioregion - Murchison	185,602	184,861	99.60		0.007
	Sub-region – Eastern Murchison	75,042	74,306	99.02		0.02
	LGA – Shire of Wiluna	39,117	38,380	98.12		0.04
223	LGA – Shire of Meekatharra	94,029	94,018	99.99	9.85	0.01
	Bioregion - Murchison	2,597	2,597	100		0.37
	Sub-region – Eastern Murchison	2,597	2,597	100		0.37
	LGA – Shire of Meekatharra	2,597	2,597	100		0.37

(Beard 1974; GoWA 2013b).

3.5.2 Other Significant Vegetation

The extent of the vegetation considered as 'other significant vegetation' that was mapped within the Impact Area is defined in Table 17. These vegetation types were generally restricted to very specific landforms and the Impact Area avoids impacting a majority of them. The Project will impact on less than 5% of each of the 'other significant vegetation' mapped within the Survey Area.

Table 17 Extent of 'Other significant vegetation' mapped within the Survey Area and Impact Area

Vegetation association	Extent in Survey Area (ha)	Extent in Impact Area (ha)	% of mapped vegetation association within Impact Area (Impact Area/ Survey Area)
VA05: Mixed low woodland on banded ironstone and chert hills	8.06	0	0
VA09: *Acacia burkittii* tall shrubland on quartz and ironstone hills	120.37	2.88	2.4
VA12: *Eremophila* low shrubland on low rocky hills	30.01	1.14	3.8
VA15: *Eucalyptus camaldulensis* woodland over mixed shrubland in ephemeral drainage lines and adjacent floodplains	251.2	6.48	2.6
VA20: Mixed low shrubland on calcareous breakaways	148.36	0.22	0.2
VA21: Mixed *Acacia* and *Eremophila* low shrubland on granite and quartz outcrops	18.97	0.9	4.7
VA22: Mixed *Acacia* tall shrubland on banded ironstone hills	31.46	0.03	0.1
VA23: Mixed low shrubland on outcrops	35.53	0.025	0.1
VA24: *Corymbia lenziana* open woodland on sand dunes	4.61	0	0

3.5.3 Conservation significant communities

No TECs were recorded within the survey area and there are no expected impacts on TECs from this project.

Subterranean Ecology (2014) assessed the potential impacts that the Project may have on CGAs (listed as a Priority 1 PEC). Their report based the assessment of impacts on the EPA's Environmental Assessment Guideline for consideration of subterranean fauna in environmental impact assessment in Western Australia (EPA 2013). The assessment determined that the potential direct and indirect impacts relevant to CGAs for this Project are:

- Excavation of rock /gravel (only if on calcrete)
- Groundwater extraction/dewatering (singe bore/bore-field if affecting calcrete aquifer)
- Changed surface topography due to compaction or creation of hard (impermeable road) surfaces resulting in increased runoff and reduced infiltration and aquifer recharge (or modified infiltration/recharge regime)

- Potential leaks (or sediment-laden runoff) resulting in alterations to groundwater quality including wastewater, introduction of toxins or radiation (e.g. hydrocarbon spills, sediments)
- Salinisation due to pit voids or intrusion (if gravel pits extend below watertable in or near calcrete)
- Vegetation clearing (road drainage and runoff) leading to sedimentation and changed nutrient inputs (only when on or near calcrete)

Subterranean Ecology (2014) determined that all of these potential impacts can be avoided, managed or mitigated to ensure that the Project does not pose an unacceptable risk to conservation of CGAs.

Subterranean Ecology (2014) determined that there is no existing evidence and a low likelihood that the proposed Project actions will pose a threat to CGAs subject to the following assumptions:

- Groundwater pumping or drawdown will not impinge on any CGAs
- Best practice operational procedures are applied to avoid and manage potential impacts to groundwater recharge and groundwater quality that might result from road building activities on or near to CGAs including drainage, gravel pits and control of leakage/spills.

Where there is a likelihood that a CGA or other calcrete deposit may be affected by the Project then it is recommended that field inspection by a suitably qualified person be undertaken to confirm that sites selected for groundwater abstraction and gravel pits are located to avoid calcrete (Subterranean Ecology 2014). Subterranean Ecology recommended that Main Roads document the location and relevant boundaries of any calcrete deposits within two kilometres of Project operations and report these to DPaW.

Should groundwater extraction be required for this Project, or the buffer distances suggested by Subterranean Ecology (2014) cannot be enforced, then further work will be requied to determine potential impacts from the Project on CGAs.

3.5.4 Conservation significant flora species

No flora species listed under the EPBC Act or the WC Act have been recorded within the Impact Area.

It is considered that the clearing required for the Project will have no impacts on flora species listed under the EPBC Act or WC Act.

Nine species listed by DPaW as Priority were recorded within the Survey Area. Two of these species occur within the Impact Area*: Ptilotus luteolus* and *Stackhousia clementii.* The population extent of these species within the state has been determined through desktop searches and is included in Table 18. The estimation of populations and plants in the whole of Western Australia, as included in Table 18, is a conservative estimate as:

- FloraBase records do not always provide details on the number of plants present. Records often provide comments such as ‘scattered’ and ‘common’ for their frequency. However, where a count was not provided the record has only been included as one plant.
- Records on FloraBase only represent those lodged with the herbarium. There may be other populations in areas not surveyed or records may not have been lodged.

Table 18 Population size of priority flora species recorded within the Impact Area and the Survey Area and known records for the state

Taxon	Status	Count in Survey Area	Count in Impact Area	State-wide record frequency	State-wide impact (# in Impact Area/ # in state)
Ptilotus luteolus	P3	2	2	14 records on Florabase, at least 460 individuals counted (WA Herbarium 1998-)	0.43
Stackhousia clementii	P3	counts averaging 180 individuals per 100 m^2.	counts averaging 180 individuals per 100 m^2.	8 records on Florabase, no counts of population size available (WA Herbarium 1998-)	unknown

The clearing of the populations of *Ptilotus luteolus* within the Impact Area is not considered likely to impact on the viability of this species as substantial populations have been recorded outside of the Impact Area. Specific impacts on *Stackhousia clementii* can not be quantified with current information but this species was noted during the field survey to occur throughout Bubble Creek within the Survey Area, not only within the Impact Area. *Stackhousia clementii* is a widespread species that occurs throughout the Carnarvon, Central Ranges, Murchison and Pilbara regions in Western Australia.

3.5.5 Introduced flora

There is potential to introduce and/or spread weed species into adjacent areas during the operational phase. The Project has the potential to:

- Increase the spread of weeds along the highway
- Introduce new weed species into the area through construction traffic and soil movement
- Introduce weeds into areas in which they did not previously occur (particularly relevant for the borrow pit areas)

However, the risk of introduction of weed species is an existing issue in the area due to the extensive disturbance from traffic and cattle. The spread of weed species is not expected to significantly increase as a result of the Project and the implementation of weed management measures should assist in minimising the risk of potential environmental impacts.

3.6 Fauna

3.6.1 Fauna habitats

Eight broad habitat types occur within the proposed Impact Area (Figure 9). Each of these habitat types are well represented in the immediate vicinity of the proposed Impact Area and in the broader Murchison region (as outlined in section 3.5.1). A summary of the area of each habitat type within the proposed Impact Area is outlined in Table 19.

The proposed Impact Area consists of approximately 510.4 ha of fauna habitat associated with remnant vegetation. The remaining 21.2 ha consists of previously disturbed areas, including existing borrow pits with and without regrowth, pastoral infrastructure and roadside margins. These disturbed areas may provide some limited habitat for native fauna.

The habitats within the proposed Impact Area are well connected both locally and regionally to native vegetation north and south of the Goldfields Highway. The proposed project would potentially reduce the overall connectivity of habitat available to the native fauna in the locality. The existing road already contributes (albeit probably only to a minor degree) to the fragmentation of habitats within the surrounding landscape. Clearing for the project, and widening the area of disturbance during construction may potentially exacerbate existing fragmentation effects and edge effects rather than completely divide a single area of habitat into two separate areas of habitat.

Construction of the project will require clearing of 510.4 ha of fauna habitat associated with remnant vegetation (Table 19). This will result in a loss of the habitat available to fauna species. The specific impacts to fauna species as a result of this loss are discussed further in section 3.6.2.

Table 19 Summary and area of each habitat type within the proposed Impact Area and value for fauna

Habitat type	Area within the proposed Impact Area (ha)	Summary of habitat value	Extent outside proposed Impact Area
Acacia shrubland over tussock grasses	345.9 ha	**Moderate** A large proportion of this habitat has been heavily disturbed via grazing and therefore lacks vegetation structure and species diversity. In areas with minimal disturbance and impacts from grazing, the habitat value is moderate.	Extensive areas of *Acacia* shrubland habitat are common in the vicinity of the proposed Impact Area and throughout the Murchison bioregion.
Acacia shrubland over hummock grasses	122.3 ha	**High** A large proportion of this habitat has been heavily disturbed via grazing and therefore lacks vegetation structure and species diversity. In areas with minimal disturbance and impacts from grazing there are mature, well-spaced hummocks interspersed with *Acacia* shrubs which provide high habitat value.	Extensive areas of *Acacia* shrubland habitat are common in the vicinity of the proposed Impact Area and throughout the Murchison bioregion.
Mixed shrubland	12.1 ha	**Moderate** A large proportion of this habitat has been heavily disturbed via grazing and therefore lacks vegetation structure and species diversity. In areas with minimal disturbance and impacts from grazing, the habitat value is moderate.	Extensive areas of *Acacia* shrubland habitat are common in the vicinity of the proposed Impact Area and throughout the Murchison bioregion.
Tussock grassland	0.15 ha	**Low** This habitat type is largely disturbed and has limited vegetation structure and diversity.	A common habitat in the Murchison bioregion.

Habitat type	Area within the proposed Impact Area (ha)	Summary of habitat value	Extent outside proposed Impact Area
Chenopod shrubland	17.9 ha	**Low** This habitat type is largely disturbed and has limited vegetation structure and diversity.	A common habitat in the Murchison bioregion which tends to be localised and associated with claypans, representing a small proposal of the total land area.
Eucalyptus/ *Corymbia* woodland (including riparian habitat around Bubble Creek)	6.48 ha	**High** This habitat type provides good structural and species diversity and a variety of habitat resources for fauna.	A common feature along more major drainage lines in the Murchison bioregion, although rare in the vicinity of the proposed Impact Area.
Rocky outcrops, breakaways and Banded Ironstone Formation (BIF) hills	5.48 ha	**High** This habitat type is less common in the surrounding area and is typically isolated and provides valuable refuge areas for fauna.	A rare feature in the landscape, representing a small proposal of the total land area.
Sand dune	0 ha (only present within the Survey Area)	**High** This habitat type was only recorded within the Survey area, and outside the proposed Impact Area. It was only recorded in one small area and is likely to rare in the surrounding area.	Very rare in the landscape and the vicinity of the proposed Impact Area. Occur more frequently to the north-east of the proposed Impact Area.
Previously cleared areas/regrowth	17.8 ha	**Low** This habitat type is largely disturbed and has limited vegetation structure and diversity.	Scattered throughout the landscape including borrow pits at various stages of regrowth.
Cleared/highly disturbed. This includes, roads, tracks, infrastructure and permanently cleared areas	3.38 ha	**Very low** This habitat type is completely disturbed and devoid of vegetation.	A common feature around major towns and near mine sites in the area.
Total area of remnant vegetation -	**510.4 ha**		
Total area of cleared/highly disturbed areas -	**21.2 ha**		
Total area-	**531.6 ha**		

3.6.1 Habitat linkages

Clearing of vegetation within the proposed Impact Area may exacerbate the existing fragmentation of the habitat but is unlikely to substantially reduce the connectivity of habitat at a local or regional scale. The potential impacts to habitat linkages resulting from clearing the proposed Impact Area predominantly relate to the widening of the existing road corridor prior to and during construction, as well as clearing for the material pits and access tracks. The habitats within the proposed Impact Area are well connected both locally and regionally to other areas of habitat. The majority of the proposed Impact Area has previously been grazed and therefore the habitats have experienced various levels of disturbance resulting in some areas being highly degraded. Therefore for the project is unlikely to substantially reduce the availability of habitat for fauna species in the local area or decrease the connectivity of habitat linkages to surrounding areas of remnant vegetation.

Furthermore the ongoing operational phase of the project is unlikely to substantially inhibit (i.e. reduce the number of movements across the road) or reduce the functionality of the habitat in the surrounding area. The upgrade to sections of the Goldfields Highway is unlikely to substantially increase the vehicle traffic utilising the highway, and therefore the potential impact of increased risk of vehicle strike is unlikely to a substantial impact of the project.

3.6.2 Conservation significant fauna

During the fauna assessment in November 2013, five conservation significant fauna species were recorded in the proposed Impact Area. In addition to these species, a number of conservation significant fauna were identified in the desktop review as potentially occurring within the proposed Impact Area. A likelihood of occurrence assessment of these species was undertaken (summarised in Table 12), and concluded that an additional six conservation significant fauna are likely to or may possibly occur in the proposed Impact Area.

Therefore a total of 11 conservation significant fauna species are known to, likely to or may possibly occur in the proposed Impact Area. The potential impacts to each of these species are discussed below.

It should be noted that a number of conservation significant fauna were assessed as unlikely to occur within the proposed Impact Area. The potential impacts to these species have not been assessed given that the project is unlikely to substantially impact on these species.

WC Act and EPBC Act listed species

The results of the desktop and field assessment identified four EPBC Act and/or WC Act listed fauna species known to, likely to or that may possibly occur within the proposed Impact Area. These include:

- Grey Falcon (*Falco hypoleucos*) – Threatened (Schedule 1) under WC Act
- Malleefowl (*Leipoa ocellata*) – Threatened (Schedule 1) under WC Act, Vulnerable under EPBC Act
- Peregrine Falcon (*Falco hypoleucos*) – Schedule 4 WC Act
- Major Mitchell's Cockatoo (*Cacatua leadbeateri*) – Schedule 4 WC Act

Grey Falcon

One Grey Falcon individual was observed perching on a dead tree within *Acacia* shrubland during the field survey, outside the proposed Impact Area. The Grey Falcon is an elusive species endemic to Australia, and also Australia's rarest falcon (Schoenjahn 2012). Given the rarity of this species, it is likely to occur in low numbers within the proposed Impact Area and opportunistically utilise all of the habitats available for hunting and dispersal. As outlined in Table 20, clearing for the project will result in a loss of 510.4 ha of suitable habitat for the Grey Falcon.

Given the availability of suitable habitat in the local area and surrounding region, and that the Grey Falcon is a wide ranging and highly mobile species, the proposed project is unlikely to have a significant impact on any individual Grey Falcon.

Malleefowl

The Malleefowl is likely to occur within the proposed Impact Area in low numbers. This species is known to occur in the region, and typically prefers habitat with a dense understorey of shrubs and their breeding habitat is characterized by light soil and abundant leaf litter, which is used in the construction of nesting mounds. The *Acacia* shrublands over tussock grasses and mixed shrubland habitat types within the proposed Impact Area are likely to provide feeding and dispersal habitat for Malleefowl. However given the grazing disturbance to a large proportion of these shrublands, these areas tend to lack the density of shrubs preferred by Malleefowl. As a result, the project area is unlikely to provide suitable breeding habitat for the Malleefowl. Therefore, the species is likely to move through the proposed Impact Area opportunistically.

As outlined in Table 20, clearing for the project will result in a loss of 358.0 ha of suitable habitat for the Malleefowl. Given the availability of suitable and better quality habitat in the local area and surrounding region, this loss of habitat is unlikely to significantly impact on Malleefowl.

During the construction phase of the Project, habitat clearance may result in the injury or death of Malleefowl individuals that would not otherwise occur in the absence of construction. As Malleefowl are likely to occur in low numbers in the areas surrounding the proposed Impact Area, the risk of this potential impact is low.

Peregrine Falcon

The Peregrine Falcon is likely to be an occasional visitor to the proposed Impact Area, and is known to occur in the region. This species occurs less frequently throughout desert regions, and therefore is likely to occur in low numbers, and opportunistically utilise the habitats within the proposed Impact Area for hunting and dispersal. This species diet predominantly consists of other birds, and to a lesser extent, small mammals, which it hunts from the air. The Peregrine Falcon nests primarily on ledges of cliffs, shallow tree hollows, and ledges of buildings in cities (Morcombe 2004). There are therefore no suitable nesting areas for this species present within the proposed Impact Area.

The Peregrine Falcon is wide ranging, mobile and aerial in nature, and therefore is likely to utilise all of the habitats within the proposed Impact Area. As outlined in Table 20, clearing for the project will result in a loss of 510.4 ha of suitable habitat for the Peregrine Falcon.

Given the availability of suitable habitat in the local area and surrounding region, and that the Peregrine Falcon is a wide ranging and highly mobile species, the proposed project is unlikely to have a significant impact on any individual Peregrine Falcon.

Major Mitchell's Cockatoo

The Major Mitchell's Cockatoo may potentially occur within the proposed Impact Area, around the Bubble Creek area. This species occurs in a wide variety of habitats, and has a requirement for trees with suitable nesting hollows and proximity to fresh surface water, and it is possible that this species utilises the habitats within the proposed Impact Area for foraging and potentially for nesting (in suitable *Eucalyptus* tree hollows within the riparian habitat around Bubble Creek). As outlined in Table 20, clearing for the project will result in a loss of 510.4 ha of foraging habitat for the Major Mitchell's Cockatoo, of which 6.48 ha is considered to provide suitable breeding habitat.

Given the wide ranging, mobile and aerial nature of this species, it is unlikely that the Major Mitchell's Cockatoo will be impacted by clearing of suitable habitats for the Project.

3.6.3 DPaW Priority listed species

The results of the desktop and field assessment identified six DPaW Priority listed fauna species known to, likely to or that may possibly occur within the proposed Impact Area. These include:

- Australian Bustard (*Ardeotis australis*) – Priority 4
- Striated Grasswren (inland sub-species) (*Amytornis striatus* subsp. *striatus*) – Priority 4
- Brush-tailed Mulgara (*Dasycercus blythi*) – Priority 4
- Bush Stone-curlew (*Burhinus grallarius*) – Priority 4
- Long-tailed Dunnart (*Sminthopsis longicaudata*) – Priority 4
- Good-legged Lerista skink (*Lerista eupoda*) – Priority 1

Australian Bustard

Australian Bustard tracks were recorded within hummock grassland habitats in the proposed Impact Area during the field survey (Figure 9). The Australian Bustard occurs across much of Australia, including across most of Western Australian, except in heavily wooded areas in the south. It occurs mainly in open country, such as grasslands, low heath or lightly wooded grassland (Morcombe, 2004). The Bustard is a nomadic bird which is known to migrate to suitable feeding areas dependent upon conditions.

It is likely that the Australian Bustard is a nomadic visitor to the proposed Impact Area, and is likely to utilise all of the habitat types for foraging. As outlined in Table 20, clearing for the project will result in a loss of 510.4 ha of suitable habitat for the Australian Bustard.

Given the availability of suitable habitat in the local area and surrounding region, and that the Australian Bustard is a wide ranging and highly mobile species, the proposed project is unlikely to have a significant impact on any individual Australian Bustard.

Striated Grasswren (inland sub-species)

The inland sub-species of the Striated Grasswren may potentially occur within the proposed Impact Area, within the *Acacia* shrublands over hummock grasses habitat type. The inland sub-species of the Striated Grasswren occurs in spinifex, preferring big old clumps on sand dunes, and in the eastern part of the range large spinifex clumps under mallee. This sub-species has a wide range from the sandy deserts of interior Western Australian through to mallee areas of north-western Victoria (Morcombe, 2004). There are two records of this species within 50 km of Goldfields Highway, and the species is known to occur in the region.

It is possible that this species utilises the habitats within the proposed Impact Area for foraging, dispersal and potentially for nesting. As outlined in Table 20, clearing for the project will result in a loss of 122.3 ha of suitable habitat for the inland sub-species of the Striated Grasswren.

Given the availability of suitable habitat in the local area and surrounding region, and that the Striated Grasswren is a highly mobile species, the proposed project is unlikely to have a significant impact on any individual of this species.

Brush-tailed Mulgara

A total of five Mulgara burrows (four active burrows and one old burrow) and one scat were recorded within spinifex grassland habitat in the proposed Impact Area. It has been assumed based on the information presented in section 2.8.6 that this is likely evidence of the Brush-tailed Mulgara (Figure 9). The Brush-tailed Mulgara is closely associated with *Triodia* Sand Plains and swales between low dunes and habitat typically consists of spinifex grasslands with medium to dense cover (Woolley 2005; Woolley *et al*. 2013). The *Acacia* shrublands over hummock grasses and habitat type within the proposed Impact Area is known and likely to provide feeding, breeding and dispersal habitat for Brush-tailed Mulgara.

As outlined in Table 20, clearing for the project will result in a loss of 122.3 ha of known habitat for the Brush-tailed Mulgara. Individual Mulgaras are known to seasonally move through the landscape utilising a network of burrows and foraging areas as resource availability shifts. Therefore, the active and/or old burrows recorded during the field survey are unlikely to provide important habitat for the Brush-tailed Mulgara given the availability of suitable habitat in the local area, and the ability for the species to utilise other areas with suitable substrate for burrows and adequate food and shelter. Therefore, clearing of habitat for the proposed project is unlikely to have a significant impact on any individual of this species.

In addition this species is susceptible to the increased risk of death or injury due to vehicle strike during both construction phase of the proposed project, particularly given that proximity of active burrows to the proposed Impact Area. As a result, individual Mulgaras may be impacted during the construction phase of the project, however this is unlikely to substantialy impact the local population or the species.

Bush Stone-curlew

One Bush Stone-curlew individual was recorded on camera trap 4, located at the dam on the north side of the highway (near SLK 741) during the field survey. It is likely that the Bush Stone-curlew is a nomadic visitor to the proposed Impact Area, and is likely to utilise all of the habitat types for foraging and dispersal. As outlined in Table 20, clearing for the project will result in a loss of 510.4 ha of suitable habitat for the Bush Stone-curlew.

Given the availability of suitable habitat in the local area and surrounding region, and that the Bush Stone-curlew wide ranging and highly mobile species, the proposed project is unlikely to have a significant impact on any individual Bush Stone-curlew.

Long-tailed Dunnart

The Long-tailed Dunnart may potentially occur within the proposed Impact Area, within the Rocky outcrops and breakaways habitat type. Sparse records exist for this species which are rare and scattered, however it may be locally common at times. In winter the Long-tailed Dunnart feeds on arthropods, including mainly beetles and ants, but also spiders, cockroaches, centipedes, grasshoppers, flies and various larvae. The records of the Long-tailed Dunnart come from widely scattered localities in the arid zone where it inhabits rugged, rocky areas including scree slopes, boulder and stony plateaus, and adjacent stony plains with shrubs over spinifex grasslands (Van Dyck *et al*. 2013)

As outlined in Table 20, clearing for the project will result in a loss of 5.48 ha of suitable habitat for the Long-tailed Dunnart.

Given the lack of suitable rocky habitat for the Long-tailed Dunnart within the proposed Impact Area, the proposed project is unlikely to have a significant impact on any individual Long-tailed Dunnart.

Good-legged Lerista skink

The Good-legged Lerista may potentially occur within the proposed Impact Area, within the *Acacia* shrubland over hummock grasses habitat type. This species occurs in open Mulga areas on loamy soils in the arid southern interior of Western Australia, between Meekatharra and Cue (Wilson and Swan 2013). It is possible that this species utilises the habitats within the proposed Impact Area for foraging, breeding and dispersal. As outlined in Table 20, clearing for the project will result in a loss of 122.3 ha of suitable habitat for the Good-legged Lerista.

Given the availability of suitable habitat in the local area and surrounding region, and that a large proportion of the suitable habitat for this species within the proposed Impact Area is heavily disturbed proposed project is unlikely to have a significant impact on any individual Good-legged Lerista.

Migratory species

The results of the desktop and field assessment identified one Migratory fauna species known to occur within the proposed Impact Area, the Rainbow Bee-eater.

Rainbow Bee-eater

Several Rainbow Bee-eaters were observed in the proposed Impact Area during the field survey. This species occurs in a variety of habitats throughout Australia and it is likely that this species is an occasional seasonal migrant to the proposed Impact Area (foraging and dispersal). No breeding of the species was recorded however suitable breeding habitat is present throughout the alignment in sandy soils. It should be noted that Rainbow Bee-eaters often take advantage of windrows of soil pushed up by graders and earth moving equipment along tracks, and may potentially use these areas within the proposed Impact Area for breeding. As outlined in Table 20, clearing for the project will result in a loss of 510.4 ha of suitable habitat for the Rainbow Bee-eater.

Given the availability of suitable habitat in the local area and surrounding region, and that the Rainbow Bee-eater wide ranging and highly mobile species, the proposed project is unlikely to have a significant impact on any individual Rainbow Bee-eater.

Table 20 Area of fauna habitat to be cleared in the proposed Impact Area

Species	Status	Suitable habitat type	Type of habitat	Area of habitat within proposed Impact Area
WC Act and the EPBC Act listed species				
Grey Falcon (*Falco hypoleucos*)	T	All habitat types	Foraging and dispersal	510.4 ha
Malleefowl (*Leipoa ocellata*)	T, V	*Acacia* shrubland over tussock grasses and mixed shrubland	Foraging and dispersal Low value breeding habitat	358.0 ha
Peregrine Falcon (*Falco hypoleucos*)	S	All habitat types	Foraging and dispersal	510.4 ha
Major Mitchell's Cockatoo (*Cacatua leadbeateri*)	S	*Eucalyptus*/*Corymbia* woodland	Foraging, breeding and dispersal	510.4 ha foraging habitat (of which 6.48 ha provides potential breeding habitat)
DPaW Priority listed species				
Striated Grasswren (inland) (*Amytornis striatus* subsp. *striatus*)	P4	*Acacia* shrubland over hummock grasses	Foraging, breeding and dispersal	122.3 ha
Australian Bustard (*Ardeotis australis*)	P4	All habitat types	Foraging and dispersal	510.4 ha
Brush-tailed Mulgara (*Dasycercus blythi*)	P4	*Acacia* shrubland over hummock grasses	Foraging, breeding and dispersal	122.3 ha
Bush Stone-curlew (*Burhinus grallarius*)	P4	All habitat types	Foraging and dispersal	510.4 ha
Long-tailed Dunnart (*Sminthopsis longicaudata*)	P4	Rocky outcrops and breakaways	Foraging, breeding and dispersal	5.48 ha
Good-legged Lerista skink (*Lerista eupoda*)	P1	*Acacia* shrubland over hummock grasses	Foraging and breeding	122.3 ha
Migratory species				
Rainbow Bee-eater (*Merops ornatus*)	Mi	All habitat types	Foraging and dispersal	510.4 ha

3.7 Land vesting and existing use

The Impact Area intersects both existing road reserves and crown land (leasehold). The extent of each type of cadastre within the Impact Area is provided in Table 21.

Table 21 Extents of cadastre (ha) within Impact Area

Cadastre	Extent within Impact Area (ha)	Location
Road reserve	126.8	Across length of Impact Area
Vacant Crown Land	76.6	Isolated sections along the Impact Area where significant realignment of the road occurs
Reserve	43.2	

The Impact Area is outside the existing designated road reserve for much of its length. Therefore due process must be followed to secure the new road within the appropriate road reserve.

The Project consists of upgrading an existing road and temporary usage of areas as borrow pits and camps. These land use activities are not considered likely to significantly impact on the current landuse of the area, which is broadscale grazing. Consultation with pastoral leaseholders within the Impact Area is recommended as a matter of courtesy and to determine any potential concerns or issues such as impact on access or fencelines due to the Project.

3.7.1 Conservation areas

There are no conservation areas within the Impact Area or within the vicinity of the Project and thus this Project is not considered to impact on any conservation areas.

The Impact Area intersects Mooloogool pastoral station, which is a proposed conservation area. Within Moologool station the Impact Area follows the existing road alignment and impacts on this station are expected to be minimal.

3.8 Environmentally Sensitive Areas

There are no ESAs within the Impact Area and the Project will not impact on any ESAs.

3.9 Contamination

The risk of contamination of the land within the Impact Area is low given the historical and current landuse of the area. The risk that the Project will impact on existing contaminated areas is low. However, if during the construction phase any potential contaminating material, such as old drums, lead or asbestos, is encountered then work should stop in this area until the potential impacts have been considered.

There is a minor risk that the construction works will create temporary or localised pollution as a result of fuel or chemical spills or mismanagement of construction materials. This risk is low and will be managed through appropriate management measures and auditing.

3.10 Visual Amenity

There will be limited visual impact from the upgrade of the Goldfields Highway. There are few residences or other sensitive areas close to the road and the impact will be limited to potential visual impacts due to construction and traffic. The traffic along the road includes local traffic as well as tourist traffic.

Machinery storage areas, stockpiling of soils and campsite establishment during works will be a temporary source of visual impact.

Potential impacts on visual amenity from the Project are likely to be minor.

3.11 Air quality and dust

Air quality impacts from the construction and use of the Highway include dust and vehicle exhaust emissions.

3.11.1 Mechanical and wind erosion dust emissions

Construction impacts

Construction dust emissions are expected to occur through:

- Earthworks, where the movement of vehicles and construction materials produces dust
- Wind erosion, where wind speed is sufficient to cause dust from stockpiles and other unprotected areas.

Whilst the amount of construction dust is expected to be measurable above background levels within the vicinity of the construction area, impacts typically occur over a short time frame and provided typical construction dust management measures are undertaken, dust impacts are expected to be minimal.

The closest residential receptors to the road alignment are located in Meekatharra, approximately 100 m away. All other receptors are greater than 100 m. Dust impacts at receptors 100 m or further from the site are expected to be minor and will be considered during the construction phase.

Operational impacts

Vehicle traffic on the Goldfields Highway between Meekatharra and Wiluna is currently relatively low. Data sourced from the Main Roads' Reporting Centre (Table 22) show such traffic counts, and indicates that a significant percentage of traffic is heavy vehicles. For this assessment it has been assumed that future traffic volumes would still be relatively small (below 100 to 200 vehicles per day).

Table 22 Traffic flow measurements in Survey Area

Site ID	Site location	Year recorded	Average daily traffic count , both directions	Average % of heavy vehicles[2]
50579	Goldfields Hwy, W of Diamond Wells Rd	2005	31	26
50580	Goldfields Hwy, E of Golf Club Road	2007	35	14
19032	Goldfields Hwy, W of Yandil Road	2010	34	35
18656	Goldfields Hwy, E of Great Northern Hwy	2012	37	27

[2] Heavy vehicles are defined as Austroads class 3-12.

Wheel generated dust emissions from the existing highway are expected to be significant, as the highway is not paved. On completion of the upgrade, which includes bituminising the highway, dust emissions from the road are expected to be minimal.

3.11.2 Vehicle exhaust

Exhaust emissions from vehicles during construction and operation include products of combustion, including carbon monoxide (CO), oxides of nitrogen (NO_x), sulphur dioxide (SO_2), coarse and fine particulate matter (PM_{10} and $PM_{2.5}$) and various volatile organic compounds (VOC).

Construction impacts

During construction activities, vehicle exhaust emissions will be generated from the current traffic load as well as construction vehicles. As indicated in Table 22, the current traffic load is expected to produce negligible impacts (due to the low traffic volumes). Whilst construction activities will have additional emissions from the construction vehicles, impacts are still expected to be insignificant.

Operational impacts

The low number of vehicles predicted to be traveling along the Highway (Table 22) indicates that pollutants from vehicle emissions are likely to be negligible.

3.12 Noise and vibration

3.12.1 Noise

Appendix G contains descriptions of noise terminology used in the section below.

Construction impact

Construction noise impacts associated with the highway upgrade were estimated using the following distance attenuation relationship[3]:

$$SPL = SWL - 20\log(d) + 10\log(Q) - 11$$

where: *d* = Distance between the source and receptor (m);
Q = Directivity index (two for a flat surface);
SPL = Sound pressure level at the distance from the source (dB); and
SWL = Sound power level of the source (dB).

Typical noise levels produced by construction plant anticipated to be used on-site were sourced from *AS 2436 – 2010 Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites* and GHD's internal database.

[3] Propagation calculations take into account sound intensity losses due to spherical spreading, with additional minor losses such as atmospheric absorption, directivity and ground absorption ignored in the calculations. As a result, predicted received noise levels are expected to slightly overstate actual received levels and thus provide a measure of conservatism.

Received noise produced by anticipated activities, during highway upgrade are shown in Table 23 for a variety of distances, with no noise barriers or acoustic shielding in place and with each plant item operating at full power. The sound pressure levels shown are maximum levels produced when machinery is operated under full load.

- The intensity and locations of construction activities;
- The type of equipment used;
- Existing local noise sources;
- Intervening terrain; and
- The prevailing weather conditions.

Construction machinery will move about the site area, altering the directivity of the noise source with respect to individual receptors. During any given period the machinery items to be used in the construction area will operate at maximum sound power levels for only brief stages. At other times the machinery may produce lower sound levels while carrying out activities not requiring full power. It is unlikely that all construction equipment would be operating at their maximum sound power levels at any one time. Finally, certain construction machinery will be present for only brief periods during construction.

Table 23 Predicted plant activity noise levels, dBA

Plant	Estimated SWL, dBA	Estimated SPL, dBA at distance (m)						
		50	250	500	750	1,000	3,000	5,000
Backhoe	104	62	48	42	39	36	26	22
Backhoe (with auger)	106	64	50	44	41	38	28	24
Bulldozer	108	66	52	46	43	40	30	26
Compactor	113	71	57	51	48	45	35	31
Compressor (silenced)	101	59	45	39	36	33	23	19
Concrete agitator truck	109	67	53	47	44	41	31	27
Concrete pump truck	108	66	52	46	43	40	30	26
Concrete saw	117	75	61	55	52	49	39	35
Concrete vibratory screed	115	73	59	53	50	47	37	33
Crane (mobile)	104	62	48	42	39	36	26	22
Excavator	107	65	51	45	42	39	29	25
Front end loader	113	71	57	51	48	45	35	31
Generator (diesel)	104	62	48	42	39	36	26	22
Grader	110	68	54	48	45	42	32	28
Hand tools (electric)	102	60	46	40	37	34	24	20
Hand tools (pneumatic)	116	74	60	54	51	48	38	34
Jack hammers	121	79	65	59	56	53	43	39
Rock breaker	118	76	62	56	53	50	40	36
Roller (vibratory)	108	66	52	46	43	40	30	26
Scraper	116	74	60	54	51	48	38	34
Truck (>20 tonnes)	107	65	51	45	42	39	29	25
Truck (dump)	117	75	61	55	52	49	39	35
Truck (water cart)	107	65	51	45	42	39	29	25
Vehicle (light commercial, 4WD)	106	64	50	44	41	38	28	24
Welder	105	63	49	43	40	37	27	23

Construction noise management

The E*nvironmental Protection (Noise) Regulations 1997* indicate that an assigned $L_{A\ 10}$ level of 45 dBA must be met at surrounding sensitive receptors (residences) during the day time (7.00 am to 7.00 pm Monday to Sunday).

However, these regulations do not apply for noise from construction activities during standard construction hours (between 7.00 am and 7.00 pm Monday to Saturday (excluding public holidays) if the construction work is:

- Carried out in accordance with control of environmental noise practices set out in Section 6 of *AS2436-1981 Guide to Noise Control on Construction, Maintenance* and Demolition Sites.
- The equipment used for construction must be the quietest reasonably available.
- Department of Environment Regulation (DER) may request a Noise Management Plan be prepared and submitted, and if so, the practices contained within the plan are complied with during construction activities.

If out of hours construction work is required (7.00 pm to 7.00 am Monday to Saturday and all hours Sundays or public holidays), in addition to the above conditions, additional requirements are:

- The contractor must advise all nearby sensitive receptors (residences) likely to receive noise levels which exceed 35 dBA of the work to be done at least 24 hours prior to commencing works
- The contractor must show that it is reasonably necessary for works to occur out of hours
- The contractor must prepare and submit a Noise Management Plan; the practices contained within the plan must be complied with during construction activities. The plan must include:
  - Reason for the construction work needing to be completed out of hours
  - Details of the activities which are likely to result in noise emissions that lead to exceeding the assigned level of 35 dBA
  - Predictions of noise emissions on the site
  - Details of measures used to control noise emissions
  - Procedures to be adopted for monitoring noise emissions
  - Complaint response procedures to be adopted

As noise from construction activities during standard construction hours is not required to meet the assigned levels, provided a Construction Noise Management Plan has been prepared there are no further requirements.

Should construction activities be required out of hours, an assessment of likely exceedance of the 35 dBA assigned level will be required.

The closest sensitive receptor to any potential noise source during construction is approximately 100 m from construction activities. From

Table 23, it is shown that some construction equipment may exceed the night time assigned level of 35 dBA, and therefore affected residences would require notification of potential noise impacts 24 hours prior to construction activities commencing.

Operational impacts

Preliminary modelling was undertaken using CadnaA, by Datakustik, which is a computer program for the calculation, assessment and prognosis of noise exposure.

CadnaA considers local topography, reflection, ground absorption, relevant building structures, site sources and the locations of the receptor areas to predict received noise levels. The method specified consists of specifically of octave-band algorithms (with nominal mid band frequencies from 31.5 Hz to 8 kHz) for calculating the attenuation of sound.

Road traffic noise predictions were undertaken using the United Kingdom Department of Transport Calculation of Road Traffic Noise (CoRTN) algorithm. The algorithm is adapted to Australian conditions by adjusting predicted noise levels by -1.7 dBA[4], and converted from $L_{A10,\ 18\ hour}$ predicted noise levels to $L_{A\ Eq\ (Day)}$ and $L_{A\ Eq\ (Night)}$ using the following relationships (GHD, 2013b) to allow for comparison with SPP 5.4 (WAPC 2009) traffic noise criteria:

- $L_{A\ Eq\ (Day)} = L_{A10\ 18\ hour} – 3$ dBA
- $L_{A\ Eq\ (Day)} = L_{A10\ 18\ hour} – 8$ dBA

The following model configuration was used:

- A conservative estimate of 100 vehicles over an 18 hour period, with 30% heavy vehicles, and 100 km/hour speed limit
- Road surface type of dense graded asphalt, and source height of 0.5 m
- No topography was used in the model, which adds further conservativeness to the model.

A sensitive receptor was placed 100 metres from the road at a height of 1.4 m to simulate predicted noise impacts at the closest receptor to the Highway. The predicted noise concentrations are adjusted by +2.5 dBA to account for building façade.

The predicted noise levels at the sensitive receptor are shown in Table 24, along with the daytime and night time SPP 5.4 criterion. As shown, the predicted noise levels are well below the criterion at the receptor.

This demonstrates that there will be negligible traffic noise impacts on nearby receptors.

Table 24 Predicted traffic noise impacts, dBA

Time of day	Predicted noise level at receptor	SPP 5.4 noise target
Day (6.00 am to 10.00 pm)	$L_{A\ Eq\ (Day)}$ =39	$L_{A\ Eq\ (Day)}$ = 55
Night (10.00 pm to 6.00 am)	$L_{A\ Eq\ (Night)}$ = 34	$L_{A\ Eq\ (Night)}$ = 50

3.12.2 Vibration

Construction impacts

Vibration impacts discussed essentially focus on potential structural damage to properties in close vicinity of the construction site and/or potentially affected by construction activities. It is possible that construction vibration will be perceived at times by local sensitive receptors. However, the level of annoyance will depend on individuals.

The nature and levels of vibration emitted by the site will vary with the activities being carried out on site. Table 25 outlines typical vibration levels for different construction activities that may be generated, sourced from the NSW Roads and Traffic Authority (RTA) *Environmental Noise Management Manual* (RTA 2001).

[4] Research undertaken by the Australian Road Research Board (ARRB, 1983)

Table 25 Typical vibration levels for construction equipment

Plant item	Peak particle velocity at 10 m (mm/s)
Backhoe	1.0
Bulldozer	2.5-4.0
Compactor (7 tonne)	5.0-7.0
Front end loader	6.0-8.0
Jack hammer	0.5
Piling	12-30
Roller (15 tonne)	7.0-8.0

Construction activity may result in varying degrees of ground vibration depending on the equipment used and methods employed. Operation of construction equipment causes ground vibrations which spread through the ground and diminish in strength with distance. Buildings founded on the soil in the vicinity of the construction site respond to these vibrations with varying results, ranging from no perceptible effects at the lowest levels, low rumbling and perceptible vibrations at moderate levels and slight building damage at the highest levels.

From Table 25, equipment proposed for site preparation and construction of the Highway will generate low levels of vibration that are unlikely to result in any vibration risks to structures. The lower limit for vibrations resulting in building damage of five mm/s is normally not exceeded by general construction activities at distances greater than 20 m from the nearest sensitive receptor.

Given the distances involved between site works and the nearest receptors, vibrations affecting human comfort and building integrity are not expected to be an issue.

Operational impacts

Vibrational impacts from road vehicles are significantly lower than those generated during construction activities. As construction vibration activities are not expected to be an issue further than 20 m from the construction area, operational vibration is also not expected to be an issue.

3.13 European Heritage

There are no European heritage sites recorded within the Survey Area and the Project is unlikely to impact on the recorded heritage sites within the townsites of Wiluna and Meekatharra.

4. Stakeholder Consultation

For this Project the Environmental Protection Agency (EPA), Department of Environment Regulation-Native Vegetation and Conservation Branch (DER) and the Department of Aboriginal Affairs (DAA) were consulted on the key approval process that Main Roads WA was going to pursue for the Portlink project. Meeting notes with the DER and EPA are shown below. The DAA consultation will not be included in this report and will be addressed in the aborginal heritage instead.

Table 26 Stakeholder consultation

Monday 22 July 2013 at 2 pm Atrium – Meeting with DER	
Attendees	Nick Jones (Project Manager), Ben Hollyock (Principal Environment Officer), Joann Johnston (Senior Environment Officer), Belinda Walker (Manager) and Simon Weighell (Assessment Officer).
Notes	
	The project was discussed in general and MRWA communicated its intent to apply for a project purpose clearing permit if advised by EPA that referral and assessment is not required. DER questioned why CPS 818 wouldn't be used and agreed that given the area of clearing and the timing that a separate permit would be best.
	It was noted that it would be ideal to have all expected clearing areas identified with MRWA's application and the option of having the application cover a larger area than needed was discussed. A purpose permit will be best and impacts to all 10 CP should be avoided so that unnecessary offsets are not required. There will not be much flexibility for the road design to be altered but the access track, material pits and camp sites can be moved to achieve this.
	Offsets were discussed and MRWA will need to start considering its plan for offsets which will be clearer once surveys have been completed and impacts are confirmed.
	Given that the clearing is not being undertaken on MRWA land then a letter of approval for access to the land will be required for Department of Lands (Formally Department of Regional Development and Lands). Alternatively a section 91 could potentially be used to gain access to land.
	The impact of water extraction from water bores was discussed. If MRWA overdraws from bores to the point where water table levels drop then there may be clearing created from vegetation loss. However the proposed works are unlikely to have this level of impact.
	Water draw down should also be assessed to consider negative impacts on organisms and ecological systems in the groundwater. Any issues associated with overdraw will need to be discussed with the Department of Parks and Wildlife (along with other threatened flora and fauna)

Tuesday 23 July 2013 at 9 am Atrium – meeting with Office of the EPA	
Attendees	Nick Jones (Project Manager), Ben Hollyock (Principal Environment Officer), Joann Johnston (Senior Environment Officer), Hans Jacob (Manager Infrastructure Projects) and Leeanne Thompson Apologies - Peta Hayward
Notes	
	A new guideline was released in June regarding application of a significance framework in EIA. In general this is what we have undertaken at desktop stage but needs to be more clearly documented. Unless there is a question regarding the significance of impact there may not be a need to talk to OEPA again.
	An arrangement will need to made with DPAW in regards to the management of road reserve in close proximity to the proposed conservation estate ex-Mooloogool Station.
	Ensure that EIA examines the impacts of the roads' upgrade on the environment not just the construction impacts for example will the traffic volume increase and types of vehicle change so that fauna deaths are increased.
	OEPA was interested in the broader PortLink project and additional information and contact was provided.
	Speak with DoW on potential impacts from water drawdown on groundwater reliant flora and fauna.

5. Additional Actions and Referrals

5.1 Additional actions required

The Project is likely to have a minor to moderate impact on a number of environmental aspects and further work and assessment is required on some of these aspects, as detailed in Table 27.

Table 27 Summary of further assessment or approval(s) required

Aspect	Action/ Permit, Approval or Licence
Land vesting	Vesting of land will need to occur as part of road reservation process.
Landuse	Consultation with pastoral leaseholders is recommended as a matter of courtesy and to determine any potential concerns or issues such as impact on access or fencelines due to the Project.
Aboriginal Heritage	Aboriginal heritage has not been considered as part of this EIA. However an Aboriginal heritage assessment has been completed separately by MRWA.
Erosion, drainage, construction issues	The EMP should be implemented during the design, construction and operational phases of the project.
Conservation significant ecological communities	Further assessment on the potential impacts of the Project on the Priority Ecological Community Concrete Groundwater Assemblages may be required.
Vegetation clearing	Unless the Project is assessed by the Environmental Protection Authority a clearing permit will be required.

5.2 Federal approvals

5.2.1 Matters of National Environmental Significance

Referral to DotE under the EPBC Act is triggered if a proposed action has/or potentially has a significant impact on any Matter of National Environmental Significance (MNES), including National Heritage values. An assessment against each of these issues is provided in Table 28.

Table 28 Assessment of the Impact Area against MNES

Matters of National Environmental Significance	Present	Impact within Survey Area
World Heritage Places	No	None.
National Heritage Places	No	None.
Ramsar Wetlands	No	None.
Threatened Species and Ecological Communities	None present One Threatened fauna species considered is likely to occur – Malleefowl (Vulnerable)	No impacts to EPBC Act listed TECs or Threatened flora. Potential impacts to the Malleefowl include loss of up to 358 ha of suitable potential habitat, however given the availability of suitable and better quality habitat in the local area and surrounding region, this loss of habitat is unlikely to significantly impact on the Malleefowl.
Listed Migratory Species	One present – Rainbow Bee-eater	Impacts to the Rainbow Bee-eater are limited to the loss of 510.4 ha of foraging and dispersal habitat. This species utilises a wide-range of habitats and is likely to use the proposed Impact Area for foraging and dispersal. However, the species is unlikely to rely on the habitats available in the proposed Impact Area, and loss of 510.4 ha of habitat is unlikely to significantly impact on the Rainbow Bee-eater.
Commonwealth Marine Areas	No	None.
Great Barrier Reef Marine Park	No	None.
Nuclear Actions	No	None.
A water resource (in relation to coal seam gas or large coal development)	No	None.

5.2.2 Significance of impacts to Malleefowl

No Malleefowl individuals or evidence of Malleefowl was recorded within the proposed Impact Area during the field survey. Therefore, the key potential impact to the Malleefowl for the proposed project is the clearing and loss of up to 358 ha of suitable potential habitat. Given the availability of suitable and better quality habitat in the local area and surrounding region, this loss of habitat is unlikely to significantly impact on Malleefowl.

In addition, during the construction phase of the project, habitat clearance may result in the injury or death of Malleefowl individuals that would not otherwise occur in the absence of construction. As Malleefowl are likely to occur in low numbers in the areas surrounding the proposed Impact Area, the risk of this potential impact is low.

5.2.3 Significance of impacts to Rainbow Bee-eater

The Rainbow Bee-eater is known to range over vast areas and utilise a wide variety of habitats throughout most of Australia (Morcombe, 2004). Several Rainbow Bee-eaters were observed in the proposed Impact Area during the field survey, and the species is known to occur throughout the region. Clearing for the project will result in a loss of 510.4 ha of suitable habitat for the Rainbow Bee-eater.

In the absence of species specific guidelines the DotE Significant impact guidelines 1.1 (DotE 2013h) was consulted to decide whether or not a referral under the EPBC Act may be required for the Rainbow Bee-eater with regard to this Project. This assessment found that the Project is unlikely to have a significant impact on the Rainbow Bee-eater, as discussed below.

The highly mobile, wide ranging behaviour of this bird means that the proposed project is highly unlikely to lead to a long-term decrease in the size of a population of Rainbow Bee-eater. This species utilises a wide variety of habitats and there is a large area of suitable habitat for the species within the local surrounding area (including habitat suitable for breeding). As outlined in section 3.5.1, clearing of the Impact Area would result in clearing of less than 0.4% of the remaining extent of Beard's (1974) vegetation association at all levels. Therefore, as the proposed Impact Area is surrounded by remnant vegetation that is likely to provide similar habitat resources for the Rainbow Bee-eater to those available within the proposed Impact Area, the loss of 510.4 ha of potential habitat is unlikely to significantly reduce the availability of suitable habitat at a local and regional scale to the extent that the species is likely to decline. The 510.4 ha of habitat is also not considered to be critical habitat for the Rainbow Bee-eater as it is known to utilise a broad range of habitat types and traverse extensive areas.

Furthermore, clearing of 510.4 ha of potential habitat for the proposed project is unlikely to significantly reduce the area of occupancy of the Rainbow Bee-eater, due to the size of the proposed clearing in relation to the vast areas occupied by individuals and the species overall. The project is also unlikely to fragment the existing population given the mobility of the bird and regional habitat connectivity.

There is the potential for clearing activities for the construction of the proposed project to disrupt the breeding cycle of individual birds during the breeding season (between November and January), in areas with sandy soils that provide suitable breeding habitat. Rainbow Bee-eaters often take advantage of windrows of soil pushed up by graders and earth moving equipment along tracks, and therefore individuals may potentially use these areas within the proposed Impact Area for breeding. However the risk of this impact is low and is unlikely to significantly impact the Rainbow Bee-eater.

5.3 State approvals

5.3.1 Environmental Protection Authority

Significant proposals must be referred to the EPA under Section 38 of the *Environmental Protection Act 1986* (EP Act).

In deciding whether a proposal will be subject to the formal environmental impact assessment process, the EPA takes into account the environmental significance of any potential impacts that may result from the implementation of the scheme or proposal.

This EIA has found the Project will have minimal adverse impacts to the surrounding environment, will only be associated with localised increases in emissions during construction, and is not likely to have a high level of public interest. The majority of the environmental impacts associated with the Project are linked to vegetation clearing and loss of fauna habitat. These potential impacts and proposed mitigation actions (and offsets, if required) for the Project can be effectively regulated through the Environmental Protection (Clearing of Native Vegetation) Regulations 2004. Therefore, it is considered the Project is unlikely to require referral to the EPA under Section 38 of the EP Act.

5.3.2 Department of Environment and Regulation

Due the the size of the Project it will not be assessed under the Main Roads CPS 818/11 statewide clearing permit. Under the *Environmental Protection Act 1986* (EP Act), clearing of native vegetation is an offence unless you have obtained a clearing permit or an exemption applies. Exemptions for low impact routine land management practices are contained in the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*. These exemptions do not apply within environmentally sensitive areas declared by the Minister for Environment under section 51B of the EP Act.

The Project will create an Impact Area of 533.74 ha including clearing of approximately 519.24 ha of native vegetation, in Condition 4 or better that will require an approved clearing permit for its removal. Clearing applications are assessed against the Ten Clearing Principles outlined under Part V of the EP Act. These principles aim to ensure that all potential impacts resulting from the removal of native vegetation can be assessed in an integrated way.

Clearing associated with the proposed Impact area has been assessed against the Ten Clearing Principles (Table 29). Clearing of the proposed Impact area (519.24 ha of native vegetation) is at variance with principle (f) and may be at variance with principle (a).

5.4 Other approvals

5.4.1 Department of Water

The RIWI Act covers the regulation, management, use and protection of water resources and irrigation in Western Australia. As the majority of the Impact Area is within an unproclaimed area water can be taken from watercourses without a licence so long as the flow is not ‘sensibly diminished’ and groundwater can be taken as long as it is not from an artesian aquifer. If water will be taken from the proclaimed areas that occur within sections of the Impact Area then a licence from the Department of Water will be required.

Table 29 Assessment of the Project against the Ten Clearing Principles

Principle	Assessment	Outcome
(a) Native vegetation should not be cleared if it comprises a high level of biological diversity.	Broadscale vegetation mapping of the area undertaken by Beard (1979) identified eight vegetation associations within the Impact Area, in associations 11, 18, 29, 39, 107, 202, 204 and 223. The extent of vegetation associations which occur within the Impact Area are greater than 98% of the pre-European extents remaining at the state, IBRA bioregion, IBRA sub-region and local government authority (LGA) levels. During the field assessment, six structural formations containing 26 vegetation associations (including two disturbance related associations) were identified within the Impact Area and described based on field observations: • Woodlands (containing four vegetation associations) (20.89 ha) • Tall shrublands (containing nine vegetation associations) (419.77 ha) • Low shrublands (containing five vegetation associations) (20.19 ha) • Tussock grasslands (containing two vegetation associations) (0.62 ha) • Hummock grasslands (containing one vegetation association) (48.93 ha) • Disturbed (containing two vegetation associations) (21.16 ha) No TECs have previously been recorded within the Impact Area, and none were recorded during the field survey. In addition no TECs are likely to occur. Three occurrences of the calcrete groundwater assemblage PEC occur within the Impact Area. This PEC will not be impacted by vegetation clearing (though it may be impacted by other elements of the Project, such as groundwater extraction which is considered further in the environmental impact assessment). There were a number of vegetation types mapped within the wider Survey Area that were considered as 'other significant vegetation' as they supported unusual species or had a role as a refuge. These vegetation types were restricted to very specific landforms and supported the majority of the DPaW Priority flora species recorded in the field survey. The Impact Area avoids the majority of these vegetation types and clearing for the Project is likely to impact on less than 5% of each of the 'other significant vegetation' mapped within the Survey Area.	May be at variance

Principle	Assessment	Outcome
	The majority of the Survey Area was rated as *Excellent* (2) to *Very Good* (3) or *Very Good* (3) (Keighery 1994 scale), with areas in the vicinity of Meekatharra and Wiluna having lower condition ratings due to increased anthropogenic disturbances observed. Areas of better vegetation condition were generally recorded from breakaways, outcrops and stony hills. Grazing by livestock, native mammals and feral animals has altered vegetation composition across the Survey Area. Grazing and trampling impacts were generally more prevalent within drainage lines and adjacent floodplain areas, as well as the margins of artificial water sources. The most noticeable areas of disturbance throughout the Survey Area included existing borrow pits, pastoral infrastructure (e.g. dams, access tracks, holding yards) and roadside margins. The vegetation condition within the Impact Area was rated during the field survey and included: • Condition 1-2 (Pristine or nearly so – Excellent) 1.22 ha • Condition 2 (Excellent) 37.65 ha • Condition 2-3 (Excellent – Very Good) 251.49 ha • Condition 3 (Very Good) 161.44 ha • Condition 3-4 (Very Good – Good) 38.32 ha • Condition 4 (Good) 29.13 ha • Condition 4-5 (Good – Degraded) 5.16 ha • Condition 5 (Degraded) 0.05 ha • Condition 5-6 (Degraded – Completely Degraded) 2.74 ha • Condition 6 (Completely Degraded) 4.4 ha A search of the *NatureMap* database (DPaW 2007–) identified 707 plant taxa, representing 62 families and 223 genera that have previously been recorded within the Study Area (50 km buffer). This total comprised 683 native flora taxa and 24 naturalised (non-native) flora taxa. A total of 398 flora taxa (including subspecies and varieties) representing 53 families and 154 genera were recorded in the Survey Area during the October 2013 field surveys. This total comprised 391 (98%) native taxa and seven (2%) introduced taxa.	

Principle	Assessment	Outcome
	No flora species listed as Threatened/DRF under the EPBC Act (DotE, 2013) or the WC Act (DPaW, 2007-) were recorded during the field survey. Nine species listed as Priority species by DPaW were recorded in the Survey Area during the field survey, and with two within the Impact Area. These two species inlcude: • *Ptilotus luteolus* (Priority 3) – 2 plants recorded within the Impact Area • *Stackhousia clementii* (Priority 3) - counts averaging 180 individuals per 100 m^2 within the Impact Area. The *Stackhousia clementii* population occurred at very large numbers both within and outside the Impact Area and counts were based on population estimates. The population was estimated to be approximately 180 individuals per 100 m^2 within the Study Area in the Bubble Creek floodplain. Given the high quantity of *Stackhousia clementii* outside the Impact Area it is unlikely that the removal of the individuals required for this project will be locally or regionally significant. A NatureMap search identified 224 fauna species as previously recorded within 50 km of the Impact Area of which 220 species are native and four are pest (introduced) species. The October 2013 field survey identified 102 fauna species, consisting of 63 birds, 19 reptiles, 19 mammals and one amphibian within the Survey Area. Of these, seven are introduced (feral) species. The field surveys identified five conservation significant fauna species within the Survey Area, including: • Grey Falcon (*Falco hypoleucos*) – Threatened under the WC Act • Australian Bustard (*Ardeotis australis*) – Priority 4 listed by DPaW • Bush Stone-curlew (*Burhinus grallarius*) – Priority 4 listed by DPaW • Brush-tailed Mulgara (*Dasycercus blythi*) – Priority 4 listed by DPaW • Rainbow Bee-eater (*Merops ornatus*) – Schedule 3 under the WC Act and Migratory under the EPBC Act Eight broad fauna habitat types were identified in the Impact Area, based on predominant landforms, soil and vegetation structure in the area The Impact Area is considered to have a similar or lower level of biodiversity to adjacent areas, at a local or bioregional scale as the Impact Area generally follows the existing road and previously disturbed areas.	

Principle	Assessment	Outcome
	The Survey Area passed through a number of landscapes that were considered to have value as areas of different geological features that supported higher levels of biodiversity of flora and fauna of the surrounding areas, such as breakaways and creeklines. However, these areas have generally been avoided by the alignment and the Impact Area predominantly encounters vegetation types and habitat types that are widespread in the general area. Much of the Impact Area occurs in an area that have been previously disturbed adjacent to the existing road. Large areas of remnant vegetation adjacent to the Impact Area, including areas (such as breakaways) that support a higher biodiversity than the Impact Area, will not be affected by this Project. The majority of the Impact Area can not be considered to support a higher biodiversity than the surrounding tracts of native vegetation. However, as the Project will impact on a population of the Priority 3 species *Stackhousia clementii* within Bubble Creek, it is considered that the Project may be at variance to this Principle.	
(b) Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia.	A search of the NatureMap database (DPaW, 2007–) identified 224 fauna species as previously recorded within the Study Area, of which 220 species are native and four are pest (introduced) species. Desktop searches of the EPBC Act PMST (DotE 2013d) and NatureMap (DPaW 2007-) databases revealed the potential presence of 18 fauna taxa protected under the EPBC Act and/or WC Act or listed by DPaW as Priority within the Study Area. In addition to these species, five conservation significant fauna species not identified in the database searches were identified as potentially occurring within the Study Area as they are known to occur in the region. These species include the Bush Stone-curlew, Major Mitchell's Cockatoo, Grey Falcon, Western Spiny-tailed Skink and Brush-tailed Mulgara. The field survey identified 102 fauna species, consisting of 63 birds, 19 reptiles, 19 mammals and one amphibian within the Survey Area. Of these, seven are introduced (feral) species. The field surveys identified five conservation significant fauna species within the Survey Area, including: • Grey Falcon (*Falco hypoleucos*) – Threatened under the WC Act • Australian Bustard (*Ardeotis australis*) – Priority 4 listed by DPaW • Bush Stone-curlew (*Burhinus grallarius*) – Priority 4 listed by DPaW • Brush-tailed Mulgara (*Dasycercus blythi*) – Priority 4 listed by DPaW • Rainbow Bee-eater (*Merops ornatus*) – Schedule 3 under the WC Act and Migratory under the EPBC Act	Not likely to be at variance.

Principle	Assessment	Outcome
	A likelihood of assessment occurrence for conservation significant fauna species concluded that an additional four species are likely to occur: • Malleefowl (*Leiopoa ocellata*) – Vulnerable and Migratory under the EPBC Act, Threatened under the WC Act • Good-legged Lerista skink (*Lerista eupoda*) – Priority 1 listed by DPaW • Long-tailed Dunnart (*Sminthopsis longicaudata*) - Priority 4 listed by DPaW • Peregrine Falcon (*Falco peregrinus macropus*) - Schedule 4 under the WC Act The likelihood of occurrence assessment also identified that two species could possibly occur within the Survey Area: • Striated Grasswren - inland (*Amytornis striatus* subsp. *striatus*) – Priority 4 listed by DPaW • Major Mitchell's Cockatoo (*Cacatua leadbeateri*) – Schedule 4 under the WC Act Eight broad fauna habitat types were identified in the Impact Area, based on predominant landforms, soil and vegetation structure in the area. Each of these habitat types is well represented in the immediate vicinity of the proposed Impact Area and in the broader Murchison region. Clearing of vegetation within the proposed Impact Area is unlikely to exacerbate the existing fragmentation of the habitat or reduce the connectivity of habitat at a local or regional scale. The potential impacts to habitat linkages resulting from clearing the proposed Impact Area predominantly relate to the widening of the existing road corridor prior to and during construction, as well as clearing for the material pits and access tracks. The habitats within the proposed Impact Area are well connected both locally and regionally to other areas of habitat. The majority of the proposed Impact Area has previously been grazed and therefore the habitats have experienced various levels of disturbance resulting in some areas being highly degraded. Therefore the project is unlikely to substantially reduce the availability of habitat for fauna species in the local area or decrease the connectivity of habitat linkages to surrounding areas of remnant vegetation. DAFWA mapping of remnant vegetation indicates that within the general region (defined as a radius of 50 km of the Survey Area) there are substantial areas of remnant native vegetation (2,670,558 ha) of which the Impact Area (534 ha) makes up 0.02% of this vegetation. Clearing of this vegetation will therefore not significantly reduce the extent of vegetation, and fauna habitat within the general area.	

Principle	Assessment	Outcome
	The Impact Area is in an area that is used for broad-scale cattle grazing and is largely uncleared. The Impact Area is surrounded by predominantly intact native vegetation and the clearing required for the Project will not clear vegetation linkages. In addition, while clearing of the Impact Area will result in a loss of known habitat for five conservation significant fauna species, four of these species are wide ranging and highly mobile birds species and therefore able to migrate to other areas of suitable habitat in the surrounding area (particularly given the availability of suitable habitat in the local area for all four of these species). The Brush-tailed Mulgara is the fifth species that is known to occur in the Impact Area. Clearing for the project will result in a loss of 122.3 ha of known habitat for the species. However given the availability of suitable habitat in the local area and that the species is known to seasonally move through the landscape and utilise other areas with suitable substrate for burrows and adequate food and shelter, the habitat within the Impact Area is unlikely to provide important habitat for this species. Therefore, overall the native vegetation within the Impact Area is unlikely to be necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia and the Project is not likely to be at variance to this Principle.	
(c) Native vegetation should not be cleared if it includes, or is necessary for the continued existence of, rare flora.	The desktop assessment determined that no Threatened flora species have been previously been recorded within the Study Area and no Threatened species were recorded within the Survey Area (and therefore Impact Area) during the field survey. A likelihood of occurrence assessment of conservation significant species (based on the range, habitat requirements and previous records of the species) did not identify any Threatened flora species as likely to occur or possibly likely to occur within the Survey Area.	Not likely to be at variance.
(d) Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of, a threatened ecological community.	A desktop assessment did not identify any TECs within the Study Area and no TECs were recorded in the Survey Area during the field survey. There is only one known TEC from the Murchison area (Depot Springs) which is not known to occur within the Meekatharra – Wiluna area. This TEC is approximately 150 km south of the Impact Area and is not likely to be directly or indirectly impacted by the Project. It is highly unlikely that any TECs occur within the Impact Area.	Not likely to be at variance.

Principle	Assessment	Outcome
(e) Native vegetation should not be cleared if it is significant as a remnant of native vegetation in an area that has been extensively cleared.	Broadscale vegetation by Beard (1974) has been adapted and digitised by Shepherd *et al.* (2002). The extent of Beard's (1974) vegetation associations have been determined by the state-wide vegetation remaining extent calculations maintained by the DPaW (latest update 2012 -Government of Western Australia 2013c). The extent of vegetation associations 11, 18, 29, 39, 107, 202, 204 and 223, which occur within the Impact Area, is greater than 98% of the pre-European extent remaining at the state, IBRA bioregion, IBRA sub-region and local government authority (LGA) levels. Clearing of the Impact Area would result in clearing of less than 0.4 per cent of the remaining extent of Beard's (1979) vegetation association at all levels. The clearing required for the Project is unlikely to have a significant impact on the regional vegetation extents. DAFWA mapping of remnant vegetation indicates that the within the general region (defined as a radius of 50 km of the Survey Area) there are substantial areas of remnant native vegetation (2,670,558 ha) of which the Impact Area (534 ha) makes up 0.02% of this vegetation. Clearing of this vegetation will not significantly reduce the extent of vegetation within the general area. The Impact Area is in an area that is used for broad-scale cattle grazing and is largely uncleared. Native vegetation will remain adjacent to the Impact Area and the clearing of the Impact Area is not likely to clear vegetation linkages.	Not likely to be at variance.
(f) Native vegetation should not be cleared if it is growing in, or in association with, an environment associated with a watercourse or wetland.	No wetlands were identified in the Impact Area in the desktop or field assessments. No defined drainage channels or rivers listed under the RIWI Act occur within the Impact Area. However, there are a number of minor ephemeral drainage channels that intersect the Impact Area including Bubble Creek at the eastern end. Throughout the Study Area defined drainage channels in the hilly areas tend to give way rapidly down-valley to alluvial floors and to broader alluvial plains with very restricted channelling (Mabbutt *et al.* 1963). As a result, most of the run-off forms widespread shallow flooding, which is subject to rapid evaporation. The ephemeral watercourses within the Impact Area contain associated vegetation mapped as the following vegetation types: • VA15 '*Eucalyptus camaldulensis* woodland over mixed shrubland in ephemeral drainage lines and adjacent floodplains' 6.5 ha within the Impact Area • VA02 '*Acacia aptaneura* low woodland' 2 ha within the Impact Area The Project will require the clearing of 8.5ha of vegetation associated with ephemeral drainage lines and as such will be at variance to this Principle.	At variance.

Principle	Assessment	Outcome
(g) Native vegetation should not be cleared if the clearing of the vegetation is likely to cause appreciable land degradation.	The Department of Mines and Petroleum Interactive Geological Map (GeoVIEW.WA) database indicates that the Study Area is underlain by alluvial, shoreline and aeolian deposits (DMP 2014). The outstanding feature of the soils of the Wiluna-Meekatharra region is their generally leached nature and the widespread siliceous hard-pan or “cement”. Very sandy soils in sand plan on wanderrie banks are the only widespread deep soils. There are some alluvial soils in valleys. Shallow, stony soils are found extensively on hill slopes and plateaus (Mabbutt *et al.*1963). The land management issues associated with the 13 land systems that occur within the Impact Area include (Mabbutt *et al.* 1963; Curry *et al* 1994): • Wiluna Land System – Not specified • Belele Land System – Minor susceptibility to soil erosion when degraded • Gabanintha Land System – Not generally susceptible to grazing-induced erosion • Sherwood Land System – Major units not generally susceptible to erosion, but some units susceptible to accelerated erosion • Yanganoo Land System – Major unit locally susceptible to accelerated erosion • Bullimore Land System – Not normally susceptible to erosion, minor wind erosion following burning • Trennaman Land System – Not specified • Glengarry Land System – Not specified • Cunyu Land System – Mild susceptibility to accelerated erosion on some units • Dural Land System – Not specified • Diamond Land System – Not specified • Jundee Land System – Concentrated drainage zones are mildly susceptible to accelerated erosion when degrade, hardpan plains otherwise not normally susceptible to erosion unless severely degraded • Violet Land System – Some units slightly susceptible to accelerated erosion	Not likely to be at variance.

Principle	Assessment	Outcome
	Based on the land system mapping, the majority of the soils of the Impact Area have a low risk of wind erosion, though some of the systems have moderate to high susceptibility to accelerated erosion. The floodplain areas are more susceptible to water and wind erosion than the soils of the plains which are generally protected from erosion by stony pavements and siliceous hard-pan. The majority of the clearing that is required will occur on plains that have some protection against erosion. There is some risk of wind and water erosion in floodplain areas; however, the extent of clearing required for this Project is low compared to the remaining tracts of native vegetation surrounding the Impact Area. In addition the cleared areas will only be temporarily cleared and will be either sealed by bitumen or rehabilitated, minimising the extent of areas of open or disturbed ground and the time that the soils will be susceptible to erosion. A review of the ASRIS risk mapping (ASRIS 2013) indicates that the Survey Area is mapped as 'Extremely Low Probability of Occurrence/Very Low Confidence' for Acid Sulphate Soils (ASS). The confidence level for this mapping is a provisional classification inferred from surrogate data with no on ground verification. Large tracts of native vegetation remain adjacent to the Impact Area which, reduce the potential direct impacts of the Project on soil acidity and salinity. The linear, narrow and temporary (prior to sealing of the road or revegetation) nature of the clearing required for this Project and the widespread siliceous hard-pan and stony mantle of much of the areas means this clearing is not considered likely to increase wind or water erosion, ground water recharge, surface water runoff or nutrient export. As such, the Project is not likely to be at variance to this Principle.	
(h) Native vegetation should not be cleared if the clearing of the vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation area.	The Impact Area does not intersect any conservation reserves and there are no conservation areas in the vicinity of the Survey Area. The Impact Area intersects Mooloogool pastoral station which is a proposed conservation area. Mooloogool Station holds no reservation status at this time. The clearing of the Impact Area within Mooloogool Station is unlikely to have a significant impact on the station as the Impact Area occurs within an existing road reserve and alongside the existing cleared highway. The Impact Area is surrounded by pastoral areas that have not been subject to large scale clearing and vegetation corridors surrounding the Impact Area remain largely intact. Clearing of the Impact Area is not likely to impact on vegetated linkages within the regional context. As such, the Project is not likely to be at variance to this Principle.	Not likely to be at variance

Principle	Assessment	Outcome
(i) Native vegetation should not be cleared if the clearing of the vegetation is likely to cause deterioration in the quality of surface or underground water.	The Impact Area is located in the Murchison River and Salt Lake Basin Surface Water Allocation Areas, within the Murchison River and Salt Lake Basin Surface Water Allocation Sub-areas. This area is not listed under the RIWI Act. A search of the DoW Geographic Data Atlas (DoW 2013) indicated that the entire Impact Area is within the East Murchison Groundwater Area. No Public Drinking Water Source Areas occur within the Impact Area, and no wetlands were identified in the Impact Area in the desktop or field assessments. No defined drainage channels or rivers listed under the RIWI Act occur within the Impact Area. There are a number of minor ephemeral drainage channels that intersect the Impact Area including Bubble Creek at the eastern end. There may be minor short term impacts on these creeklines during construction clearing, including potential erosion of the soil adjacent to the road during construction. However, the Project is not expected to clear vegetation that would significantly alter current surface water drainage in the long term. Existing road drains and other drainage (natural or constructed) will be re-constructed after completion of the Project, and therefore the Project is not expected to alter current surface water drainage in the long term. In addition construction will occur during the dry season which means that the creeklines are unlikely to be flowing during construction. This reduces the risk of impacting on surface water flows during construction. As indicated in principle (g) the probability of ASS occurring is low to extremely low. Borrow pits will be cleared and rehabilitated progressively to minimise potential erosion and sedimentation impacts. As the Project is unlikely to impact on surface water flows or groundwater quality or quantity, the Project is not likely to be at variance to this Principle.	Not likely to be at variance
(j) Native vegetation should not be cleared if the clearing of the vegetation is likely to cause, or exacerbate, the incidence or intensity of flooding.	The Impact Area crosses two catchment areas: ‘Murchison River’ and ‘Salt Lake Basin’. The Murchison River has a catchment area of 8,200,000 ha and the Salt Lake Basin is 49 000,000 ha (Shepherd *et al.* 2002). The Impact Area (534 ha) comprises a very small extent of both of these catchments and is not likely to influence the potential flooding or waterlogging of the catchment areas. Given the narrow, linear nature of much of the Impact Area and the fact that the majority of the clearing required for the Project will occur along the existing road, the Project is unlikely to increase the risk of flooding or waterlogging within the area. In addition construction will occur within the dry season when rainfall is limited and areas of temporary clearing will be rehabilitated following construction.	Not likely to be at variance

Principle	Assessment	Outcome
	Borrow pits will be cleared and rehabilitated progressively to minimise potential runoff issues associated with cleared areas in the borrow pits. Given the linear nature of the Impact Area and the large extents of remnant vegetation remaining adjacent to the Impact Area, the clearing required for the Project is unlikely to increase the risk of flooding or waterlogging within the Impact Area. Levees and drainage works will be undertaken as part of the roadworks which will assist in management of drainage adjacent to the highway. Given the above the Project is unlikely to impact the incidence of intensity of flooding, the Project is not likely to be at variance to this Principle.	

6. Environmental Management Plan

6.1 Environmental Management Plan

Main Roads will work to minimise impacts upon the environment associated with road construction projects.

A project specific Environmental Management Plan (EMP) should be implemented to manage potential environmental impacts associated with the project. The EMP should include management measures to:

- Minimise clearing of vegetation through the design and construction process and prevent unauthorised clearing
- Minimise the risk of erosion through design and construction processes
- Manage any contamination identified during works
- Control dust generation including standard dust suppression techniques such as the use of water carts
- Manage pollution generating activities such as refuelling or storage of chemicals during works
- Manage hazardous substances on site in accordance with material safety data sheets
- Control the introduction or spread of Declared Plants and weeds

The aim of this EMP is to minimise the environmental impacts associated with the proposed works as well as to identify areas of responsibilities required for the implementation of management strategies.

This EMP addresses specific issues that were identified during the EIA. The project management measures identified within this EMP are in addition to the standard environmental management contract specifications. Main Roads' standard environmental contract specifications (Specifications 203, 204, 301, 302 and 304) are to be adhered to where appropriate.

The areas that require special management will be addressed in terms of:

- The timing of the various management actions
- The topic (e.g. vegetation)
- The objectives for each area
- The actions that are necessary to minimise the impact
- The responsible party for implementing the action
- Whether the action arose from external advice or is a Main Roads requirement

6.2 Communication plan

Environmental issues specific to the project will be communicated as follows:

Table 30 Communication plan

Method	Frequency	Participants	Reference	Record
Project Site				
Induction	Prior to Work	All personnel and subcontractors	EMP and Contractor Environmental Policy	Induction Meeting
Toolbox Meetings	Daily	Project Personnel	Contractor Safety Plan	Minutes of Meeting
Contract Meetings	Monthly	Main Roads' Project Manager and Contractor Project Manager	EMP	Minutes of Meeting

6.3 External communication and complaints

A complaints register shall be maintained by the contractor. All complaints received shall be forwarded to the Main Roads' Project Manager for action. Serious complaints shall be investigated within 24 hours of the complaint being received.

6.4 Monitoring

After project completion and project handover, the Asset manager should develop a monitoring program to monitor for those aspects that have been identified as requiring monitoring.

6.5 Auditing

The implementation of the EMP will be audited after the contractor takes possession of site. The audit schedule will be determined dependent on the construct clearing schedule. Audits will be carried out quarterly as a minimum. This audit will be carried out by a Main Roads staff member.

A suitability audit of the Construction Environmental Management Plan (CEMP) will be completed prior to works commencing.

Table 31 Environmental Management Plan Accountability

Name	Role	Contact details
Nick Jones	Project Manager	9080 1457 nick.jones@mainroads.wa.gov.au
Emma Fitzgerald	Environmental Officer	9323 5435 emma.fitzgerald@mainroads.wa.gov.au

Table 32 Environmental Management Plan

ENVIRONMENTAL MANAGEMENT PLAN					
Topic	**Objective**	**Management Action**	**Monitoring/ Maintenance Program**	**Responsible Party**	**Completion Timeframe**
Environmental Management System					
Record Keeping	Maintain record keeping requirements	• Ensure standard record keeping requirements are completed within three months of completion of the project activities	Management system review	Environment Officer	Three months following completion of construction
Inductions	Ensure that all construction personnel and contractors are aware of environmental requirements.	• Develop and implement an Environmental induction program to include training in the requirements of this EMP. • Ensure all personnel and constractors attend the induction training and keep records of their attendance.	Management system review	Environment Officer	End of construction period.
Project Specific Aspects					
Dust	Manage dust so that it does not create adverse social or environmental impacts	• Clear vegetation only when necessary and treat areas requiring soil stabilisation as soon as practicable. • Water tankers will be made available to dampen exposed surfaces within construction and laydown areas, particularly during ground disturbing activities. • Minimise or cease project activities during periods of high wind or when excessive dust is generated. • Access to private property and appropriate traffic management measures should be planned and implemented prior to the construction of works. • Watering, road sweeping and signage for suitable speed limits will be used during vehicle movement.	Construction surveillance/ complaints register	Contractor/Project Manager	Ongoing through construction phase

ENVIRONMENTAL MANAGEMENT PLAN					
Topic	**Objective**	**Management Action**	**Monitoring/ Maintenance Program**	**Responsible Party**	**Completion Timeframe**
		• Appropriate licences from the Department of Water will be obtained if required to supply water for dust suppression and other construction purposes. • The extent of cleared and other disturbed areas will be minimised as far as is practicable for construction requirements. • If stockpiles are left untouched for greater than 28 days long-term stabilisation methods such as mulch or other stabilisers should be implemented. • All vehicles carrying dusty loads will be covered through the use of tarpaulins etc. when travelling in areas with sensitive receptors both inside and outside the project area.			
Pollution and Litter	Ensure that the construction of the proposal is managed to a standard that minimises any adverse impacts on the environment. Appropriate disposal of construction waste.	• All waste materials from the project area will be removed from the site upon completion of the project and to the satisfaction of the Project Manager or Site Superintendent. • Construction waste and other rubbish will be contained in bins with lids (where practicable) and removed regularly. • Confirm that non-recyclable materials/wastes are disposed of at licensed landfill facilities or in accordance with Council regulations. • Temporary storage of bitumen, asphalt, concrete or aggregate should only occur at designated depots or controlled hardstands. Precoating of aggregate will only occur in approved areas.	Construction surveillance	Environment Officer	Ongoing through construction phase

ENVIRONMENTAL MANAGEMENT PLAN					
Topic	**Objective**	**Management Action**	**Monitoring/ Maintenance Program**	**Responsible Party**	**Completion Timeframe**
		• Emergency clean-up procedures shall be implemented in the case of any spillage. These will include control of spilled material and removal of contaminated soil to an approved site. The contractor shall ensure appropriate equipment is available at all times and shall notify the Superintendent's Representative of a spill. • Employees whose activities include the storage and handling of waste have been appropriately trained and are competent at undertaking tasks required. • All waste oil will be collected for recycling and any empty fuel/oil containers, used filters and waste hydraulic parts to be collected and stored in an allocated area then removed to an approved landfill site. • Re-fuelling on site should be avoided as much as is practical. • The Project Area will be kept in a tidy manner at all times.			
Surface Drainage	Prevent damage to environment from changes to flood regime and maintain hydrological regime that exists prior to construction.	• Vegetation removal and soil disturbance will be minimised, where practicable. • Disturbed areas will be stabilised soon after construction activities are completed. • Existing natural drainage paths and channels along the road or the vicinity of the project area will not be unnecessarily blocked or restricted during project construction. • Vehicle and equipment wash down areas will be located away from environmentally sensitive areas.	Pre-construction/ construction surveillance.	Project Manager	Ongoing through construction phase

ENVIRONMENTAL MANAGEMENT PLAN					
Topic	**Objective**	**Management Action**	**Monitoring/ Maintenance Program**	**Responsible Party**	**Completion Timeframe**
		• Maintain the hydrological balance on each side of the road. This will prevent ponding and scour during flood events, and with appropriate management structures in place (such as culverts) balance will be maintained. Stormwater drainage shall be treated and disposed of in accordance with Main Roads requirements.			
Groundwater	To maintain the quality of groundwater so that existing and potential environmental values are protected.	• Spills of > 5L of hydrocarbons or potentally polluting materials will be contained immediately and removed within 24 hours to minimise the potential for contaminants to enter groundwater. • Use pollution control and containment strategies during the construction phase of the project and liaise with the DoW where necessary. • If dewatering is required, Main Roads will gain approvals from DoW. – If dewatering is required, the most appropriate method will be determined on site and dewatering kept to a minimum necessary for the safe construction; – As far as practicable, infiltrate dewater back into the groundwater resource, close enough to the abstraction point that is does not create a 'recycle' effect • The Construction Contractor will design, maintain and operate all necessary pumping equipment and temporary structures for dewatering.	Construction surveillance	Contractor/Project Manager	Ongoing through construction phase

ENVIRONMENTAL MANAGEMENT PLAN					
Topic	**Objective**	**Management Action**	**Monitoring/ Maintenance Program**	**Responsible Party**	**Completion Timeframe**
Hazardous Materials	Ensure that the construction works are managed to a standard that minimises any adverse impacts on the environment.	• Bulk fuel and hazardous material storage areas should be excluded from the site (and stored in Meekatharra or Wiluna) as far as is practical. • Regular vehicle servicing will be undertaken at designated areas, at least 100 m away from watercourses or in Meekatharra or Wiluna as much as is practical. • Site personnel shall be trained in the use of emergency Fire suppressant equipment. • Spill trays and spill response equipment will be available near fuel storage or refuelling areas. • All hazardous material spills will be reported according to statutory requirements. • Hazardous materials will be disposed of at an approved and certified facility. • Temporary storage of bitumen, asphalt, concrete or aggregate shall occur at designated depots or controlled hardstands located within the project area. • Pre-coating of aggregate will only occur in approved and designated areas.	Construction surveillance	Contractor/Project Manager	Ongoing through construction phase
Fire	Ensure that the fire risk associated with the construction of the proposal is minimised.	• No fires shall be lit within the project area. • Cleared vegetation will not be burned on site. • Machinery will be fitted with approved spark arresting exhaust systems. • All vehicles, plant and equipment to be fitted with fire extinguishers and restricted and to designate cleared areas.	Construction surveillance	Contractor/Project Manager	Ongoing through construction phase

ENVIRONMENTAL MANAGEMENT PLAN					
Topic	**Objective**	**Management Action**	**Monitoring/ Maintenance Program**	**Responsible Party**	**Completion Timeframe**
		• Maintain all vehicles, plant and equipment in good working order free of build-up of debris and oil. • A water tanker/fire fighter unit will be on site at all times during project construction and personnel trained in their use. • Develop and maintain a risk assessment of all construction activities. All hot works will be undertaken in accordance with standard safety procedures. When construction activities are deemed to be a moderate or high fire risk, specific fire management actions should take place such as wetting down the work area and having a dedicated spotter to watch work for fire ignition. • Reduce the amount of flammable substances stored on site (such as fuel) to the minimum required. Where possible all flammable substances should be kept off site. Where that is not practical, flammable substances should be kept in an area that is free of ignition sources and clearly identified and registered. • Construction personnel will attempt to extinguish (using safe working methods) and report fires occurring within the project area.			
Revegetation/ Rehabilitation activities	Rehabilitate temporarily cleared areas as close as practicable to a natural state	• A revegetation plan will be prepared that includes the following: – A figure showing areas to be regenerated – Requirements for vegetation reuse – Requirements for topsoil storage and reuse and/or soil preparation or treatment – Completion criteria for revegetation success	Construction surveillance and post construction maintenance assessment	Environment Officer	Preparation (top soil stockpiling as required) during construction phase Revegetation completed as

ENVIRONMENTAL MANAGEMENT PLAN					
Topic	**Objective**	**Management Action**	**Monitoring/ Maintenance Program**	**Responsible Party**	**Completion Timeframe**
		• Implement the Revegetation Plan to revegetate/rehabilitate areas cleared for temporary purposes. Revegetation will be undertaken in accordance with Main Roads' 'Guideline Revegetation Planning and Techniques (TRIM Doc D12#258089)'. • Any revegetation/regeneration works will only include plant species which are indigenous to the local area. • Revegetation will aim to produce a self-sustaining vegetation community that is as similar to the surrounding vegetation as possible.			soon as is practical after completion
Topsoil	Determine adequate topsoil management in order to enhance revegetation success and minimise erosion and spread of weeds.	• Topsoil will be managed according to Main Roads Topsoil Management Guideline (TRIM Doc D12#256186). • Topsoil will be stockpiled for revegetation purposes and the movement of topsoil will be restricted to the limits of the project area. • Construction activities will be undertaken where possible in the dry season to reduce the potential for soil erosion and drainage line siltation due to vegetation removal and heavy rains.	Construction surveillance	Project Manager/ Contractor	Ongoing through construction phase and revegetation works
Clearing of vegetation and fauna habitats	Minimise direct loss of vegetation and fauna habitats.	• Selection of design that minimises direct and indirect impacts on native vegetation and habitat in the Project area. Where possible design should minimise vegetation clearing.	Design phase	Main Roads	Design Phase
		• Plan and develop storage sites, laydown areas, hardstands and other areas which require clear space to occur within areas which are already cleared, otherwise disturbed or proposed to be cleared.	Construction surveillance	Project Manager/ Contractor	Ongoing through construction phase

ENVIRONMENTAL MANAGEMENT PLAN					
Topic	**Objective**	**Management Action**	**Monitoring/ Maintenance Program**	**Responsible Party**	**Completion Timeframe**
		• Vehicles and equipment shall not be driven over, or parked on, vegetation / habitat as far as is practicable.	Construction and revegetation surveillance		
		• Avoid clearing known locations of priority flora species and communities (where possible) or minimise impacts to conservation significant flora. Priority flora species (listed by DPaW) identified during the GHD field survey (2013) include: – *Eremophila congesta* (Priority 1) – *Calytrix uncinata* (Priority 3) – *Calytrix verruculosa* (Priority 3) – *Gunniopsis propinqua* (Priority 3) – *Homalocalyx echinulatus* (Priority 3) – *Indigofera sp. Gilesii* (M.E. Trudgen 15869) (Priority 3) – *Ptilotus luteolus* (Priority 3) – *Sauropus ramosissimus* (Priority 3) – *Stackhousia clementii* (Priority 3) • Conservation significant flora nd communities will be clearly marked on site and on clearing plans. Fencing shall be placed to delineate the Project Area from conservation significant flora and communities where they are not to be cleared or otherwise impacted.	Construction surveillance		
		• Restrict the extent of clearing in habitat considered to be significant for conservation significant fauna. In particular, restrict and minimise clearing habitat in the areas surrounding identified Brush-tailed Mulgara (Priority 4) burrows and suitable habitat (122.3 ha, see Table 20).	Construction surveillance		

ENVIRONMENTAL MANAGEMENT PLAN					
Topic	**Objective**	**Management Action**	**Monitoring/ Maintenance Program**	**Responsible Party**	**Completion Timeframe**
		• Restrict the extent of clearing in habitat considered to be significant for conservation significant fauna, and rare in the region, including: – For the Major Mitchell's Cockatoo (Schedule 4) – Eucalyptus/ Corymbia woodland (including riparian habitat around Bubble Creek) (6.48 ha) – For the Long-tailed Dunnart (Priority 4) – Rocky outcrops, breakaways and BIF hills (5.48 ha)			
		• A clearing line will be clearly marked onsite by a surveyor in accordance with the design. This line will be checked by a member of the Environmental Team (with appropriate experience) prior to the commencement of clearing works	Construction surveillance	Environment Officer/Contractor	Ongoing through construction phase and revegetation works
		• Trees to be removed shall be felled in a manner that they fall within the approved clearing area.	Construction surveillance	Environment Officer/Contractor	Completion of clearing
Vegetation Clearing - Record-keeping	Maintain the required records relating to clearing native vegetation under the purpose permit.	• Clearing Record Keeping required: – A map showing the location where the clearing occurred (ESRI shapefile) – The size of the area cleared (in hectares) – The dates on which the clearing was done		Project Manager	Ongoing through construction phase and revegetation works
Weeds	Minimise impact of weeds in the Project Area	• If any weeds of significance are recorded in the Project Area during construction the Environmental Officer will manage the weeds in accordance with legislated requirements. • Plant, machinery, equipment, tools and footwear will be cleaned down prior to arrival and prior to departure from the site. Clean down will consist of brushing, gouging, scraping and/or water blasting to remove any compacted soil or plant matter.	Construction surveillance	Environment Officer/Contractor	Ongoing through construction phase and revegetation works

ENVIRONMENTAL MANAGEMENT PLAN					
Topic	**Objective**	**Management Action**	**Monitoring/ Maintenance Program**	**Responsible Party**	**Completion Timeframe**
		• A weed control program will be implemented for revegetation areas as required. This will involve spraying weeds appropriately to maximise the success of revegetation works and reduce the spread of weeds.			
Fauna	Avoid unnecessary impacts to fauna and damage to fauna habitat.	• Fauna are not to be fed or intentionally harmed. • Timing of clearing should avoid the peak breeding period for threatened and priority fauna known to occur in the Project Area: – Mulgara (*Dasycercus cristicauda*) – Rainbow Bee-eater (*Merops ornatus*) – Australian Bustard (*Ardeotis australis*) – Bush Stone-curlew (*Burhinus grallarius*) – Grey Falcon (*Falco hypoleucos)* • No pets or firearms permitted on site. • The nearest DPaW office is to be contacted in the event of sick, injured or orphaned native wildlife on the site. • The Environment Officer should be aware of the contact details and availability of veterinary services and wildlife careers in Wiluna or Meekatharra. • Any trenched or open excavations should be checked twice daily (within two hours of dawn and within two hours of dusk) for fauna and any entrapped fauna will be removed as soon as possible by an appropriately experienced person.	Construction surveillance	Project Manager/ Contractor/ Environment Officer	Ongoing through construction phase and revegetation works

ENVIRONMENTAL MANAGEMENT PLAN					
Topic	**Objective**	**Management Action**	**Monitoring/ Maintenance Program**	**Responsible Party**	**Completion Timeframe**
		• Fauna encountered in the construction area shall be given the chance to move on if there is no threat to the person's safety in doing so. The Environmental Coordinator will be suitably experienced and licensed and will be available at all times during the construction phase to interact with fauna that cannot move away freely. • Any logs or other material which has value as habitat for fauna is to be stockpiled and replaced on the revegetation area (where possible). • Minimise or restrict the movement and use of plant and vehicles at dusk and dawn and during night time hours.			
Traffic	Minimise the disturbance from traffic	• Construction vehicles will travel along specifically designated routes that have been selected to minimise disturbance on other traffic and the community.	Construction surveillance/complaints register	Contractor	Ongoing through construction phase and revegetation works
Visual Amenity	Minimise impacts to visual amenity for local and tourist traffic	• Machinery storage areas, stockpiling of soils and campsite establishment during works to be located in areas which minimise any visual amenity impacts	Construction surveillance/complaints register	Project Manager	Pre-construction

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Appendices

Appendix A – Legislation, background information, and conservation codes

Legislation

Federal Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is the Federal Government's central piece of environmental legislation. It provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places, which are defined in the EPBC Act as matters of national environmental significance (MNES).

There are currently nine MNES protected under the EPBC Act, these include:

- World heritage properties
- National heritage places
- Wetlands of international importance (listed under the Ramsar Convention)
- Listed Threatened species and ecological communities
- Migratory species
- Commonwealth marine areas
- The Great Barrier Reef Marine Park
- Nuclear actions (including uranium mines)
- A water resource, in relation to coal seam gas development and large coal mining development

A person must not undertake an action that has, will have, or is likely to have a significant impact (direct or indirect) on MNES, without approval from the Australian Government Minister for the Environment.

State *Environmental Protection Act 1986*

The *Environmental Protection Act 1986* (EP Act) is the primary legislative Act dealing with the protection of the environment in Western Australia. It provides for an Environmental Protection Authority (EPA), for the prevention, control and abatement of pollution and environmental harm, for the conservation, preservation, protection, enhancement and management of the environment and for matters incidental to or connected with the above.

State Environmental Protection (Clearing of Native Vegetation) Regulations 2004

Clearing of native vegetation in Western Australia requires a permit from the Department of Environment and Regulation (DER) (formerly the Department of Environment and Conservation – DEC), unless exemptions apply. Native vegetation includes aquatic and terrestrial vegetation indigenous to Western Australia, and intentionally planted vegetation declared by regulation to be native, but not vegetation planted in a plantation or planted with commercial intent.

In the EP Act Section 51A, clearing is defined as the killing or destruction of; the removal of; the severing or ringbarking of trunks or stems of; or the doing of substantial damage of some or all of the native vegetation in an area, including the flooding of land, the burning of vegetation, the grazing of stock or an act or activity that results in the above.

When making a decision to grant or refuse a permit to clear native vegetation the assessment considers clearing against the ten clearing principles as specified in Schedule 5 of the EP Act:

a. Native vegetation should not be cleared if it comprises a high level of biodiversity.

b. Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of a significance habitat for fauna indigenous to Western Australia.

c. Native vegetation should not be cleared if it includes, or is necessary, for the continued existence of rare flora.

d. Native vegetation should not be cleared if it comprises the whole or part of native vegetation in an area that has been extensively cleared.

e. Native vegetation should not be cleared if it is significant as a remnant of native vegetation in an area that has been extensively cleared.

f. Native vegetation should not be cleared if it is growing in, or in association with, an environment associated with a watercourse or wetland.

g. Native vegetation should not be cleared if the clearing of the vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation area.

h. Native vegetation should not be cleared if the clearing of the vegetation is likely to cause appreciable land degradation.

i. Native vegetation should not be cleared if the clearing of the vegetation is likely to cause deterioration in the quality of surface or underground water.

j. Native vegetation should not be cleared if clearing the vegetation is likely to cause, or exacerbate, the incidence of flooding.

There are a number of Environmentally Sensitive Areas (ESAs) within Western Australia where exemptions in regulations do not apply. ESAs include locations of threatened communities and species.

ESAs are declared by a notice under Section 51B of the EP Act. Table A.1 outlines the aspects of areas declared as ESA (under the Environmental Protection (Clearing of Native Vegetation) Regulations 2004 – Reg 6).

Table A.1 Aspects of Environmentally Sensitive Areas

Aspects of Environmentally Sensitive Areas
A declared World Heritage property as defined in Section 13 of the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).
An area that is registered on the Register of the National Estate (RNE), because of its natural values, under the Australian Heritage Commission Act 1975 of the Commonwealth (the RNE was closed in 2007 and is no longer a statutory list – all references to the RNE were removed from the EPBC Act on 19 February 2012).
A defined wetland and the area within 50 m of the wetland.
The area covered by vegetation within 50 m of rare flora, to the extent to which the vegetation is continuous with the vegetation in which the rare flora is located.
The area covered by a TEC.
A Bush Forever Site.
The areas covered by the following policies:
a) The Environmental Protection (Gnangara Mound Crown Land) Policy 1992.
b) The Environmental Protection (Western Swamp Tortoise Habitat) Policy 2002.
The areas covered by the lakes to which the Environmental Protection (Swan Coastal Plain Lakes) Policy 1992 (SCPL) (EPP Lakes) applies.
Protected wetlands as defined in the Environmental Protection (South West Agricultural Zone Wetlands) Policy 1998.
Areas of fringing native vegetation in the policy area as defined in the Environmental Protection (Swan and Canning Rivers) Policy 1997.

State *Wildlife Conservation Act 1950*

The *Wildlife Conservation Act 1950* (WC Act) provides for the conservation and protection of wildlife. It is administered by the DPaW and applies to both flora and fauna.

Any person wanting to capture, collect, disturb or study fauna requires a permit to do so. A permit is required under the WC Act if removal of threatened species is required.

State *Biosecurity and Agriculture Management Act 2007*

The *Biosecurity and Agriculture Management Act 2007* (BAM Act) provides for the declaration of Declared Pests by the Department of Agriculture and Food Western Australia (DAFWA) which are prohibited organisms or organisms for which a declaration under Section 22(2) is in force.

The BAM Act replaces the repealed *Agriculture and Related Resources Protection Act 1976* (ARRP Act).

Background Information and Conservation Codes

Acid Sulphate Soils

Acid Sulphate Soils (ASS) are naturally occurring soils containing iron sulphides. These soils are typically benign within an anaerobic environment, however they can become oxidised when exposed, resulting in acidic soil and groundwater. The resulting sulphuric acid can also break heavy metal bonds and result in groundwater contamination. Acid sulphate soils are typically considered to be a management issue.

Wetlands

Wetlands include not only lakes with open water, but areas of seasonally, intermittently or permanently waterlogged soil.

Ramsar wetlands

The Convention of Wetlands of International Importance was signed in 1971 at the small Iranian town of Ramsar. The Convention has since been referred to as the Ramsar Convention. Ramsar wetlands are “sites containing representative, rare or unique wetlands, or wetlands that are important for conserving biological diversity … because of their ecological, botanical, zoological, limnological or hydrological importance” (DotE, 2013b). Once a Ramsar wetland is designated, the country agrees to manage its conservation and ensure its wise use. Under the Convention, wise use is broadly defined as “maintaining the ecological character of a wetland” (DotE, 2013b).

Nationally important wetlands

Nationally important wetlands are wetlands which meet at least one of the following criteria (DoE, 2013a):

- It is a good example of a wetland type occurring within a biogeographic region in Australia
- It is a wetland which plays an important ecological or hydrological role in the natural functioning of a major wetland system/complex
- It is a wetland which is important as the habitat for animal taxa at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions such as drought prevail
- The wetland supports one percent or more of the national populations of any native plant or animal taxa
- The wetland supports native plant or animal taxa or communities which are considered endangered or vulnerable at the national level
- The wetland is of outstanding historical or cultural significance

Vegetation and Flora

Species of significant flora, fauna and communities are protected under both Federal and State Acts. The Federal EPBC Act provides a legal framework to protect and manage nationally important flora and communities. The State WC Act is the primary wildlife conservation legislation in Western Australia.

Vegetation extent & status

The National Objectives and Targets for Biodiversity Conservation 2001–2005 (Commonwealth of Australia, 2001) recognise that the retention of 30 percent or more of the pre-clearing extent of each ecological community is necessary if Australia's biological diversity is to be protected. This is the threshold level below which species loss appears to accelerate exponentially and loss below this level should not be permitted. This level of recognition is in keeping with the targets recommended in the review of the National Strategy for the Conservation of Australia's Biological Diversity (ANZECC, 2000) and in EPA Position Statement No. 2 on environmental protection of native vegetation in Western Australia (EPA, 2000).

From a purely biodiversity perspective and taking no account of any other land degradation issues, there are a number of key criteria now being applied to the clearing of native vegetation in Western Australia (EPA, 2000).

- The "threshold level" below which species loss appears to accelerate exponentially at an ecosystem level is regarded as being at a level of 30 percent of the pre-European extent of the vegetation type.
- A level of 10 percent of the original extent is regarded as being a level representing Endangered.
- Clearing which would put the threat level into the class below should be avoided.
- From a biodiversity perspective, stream reserves should generally be in the order of at least 200 metres (m) wide.

The extent of remnant native vegetation has been assessed by Shepherd et al. (2002) and the Government of Western Australia (2013), based on broadscale vegetation association mapping by Beard (1974).

Conservation significant communities

Ecological communities are defined as naturally occurring biological assemblages that occur in a particular type of habitat (English and Blyth, 1997). Federally listed Threatened Ecological Communities (TEC) are protected under the EPBC Act administered by the Department of the Environment (DotE) (formerly the Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC)). The DPaW also maintains a list of TECs for Western Australia; some of which are also protected under the EPBC Act. TECs are ecological communities that have been assessed and assigned to one of four categories related to the status of the threat to the community, i.e. Presumed Totally Destroyed, Critically Endangered, Endangered and Vulnerable (Table A.2).

Possible TECs that do not meet survey criteria are added to the DPaW Priority Ecological Community (PEC) List under Priorities 1, 2 and 3 (Table A.3). These are ecological communities that are adequately known; are rare but not threatened, or meet criteria for Near Threatened. PEC that have been recently removed from the threatened list are placed in Priority 4. These ecological communities require regular monitoring. Conservation dependent ecological communities are placed in Priority 5. PEC are not listed under any formal Federal or State legislation.

Table A.2 Conservation codes & definitions for Threatened Ecological Communities endorsed by the Western Australian Minister for the Environment & listed under the *Environment Protection and Biodiversity Conservation Act 1999*

Status	Description
Federal Government Conservation Categories (EPBC Act)	
Critically Endangered (CR)	If, at that time, it is facing an extremely high risk of extinction in the wild in the immediate future
Endangered (EN)	If, at that time, it is not critically endangered and is facing a very high risk of extinction in the wild in the near future
Vulnerable (VU)	If, at that time, it is not critically endangered or endangered, and is facing a high risk of extinction in the wild in the medium-term future
Western Australia Conservation Categories	
Presumed Totally Destroyed (PD)	The community has been found to be totally destroyed or so extensively modified throughout its range that no occurrence of it is likely to recover its species composition and/or structure in the foreseeable future.
Critically Endangered (CR)	An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or that was originally of limited distribution and is facing severe modification or destruction throughout its range in the immediate future, or is already severely degraded throughout its range but capable of being substantially restored or rehabilitated
Endangered (EN)	An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or was originally of limited distribution and is in danger of significant modification throughout its range or severe modification or destruction over most of its range in the near future.
Vulnerable (VU)	An ecological community that has been adequately surveyed and is found to be declining and/or has declined in distribution and/or condition and whose ultimate security has not yet been assured and/or a community that is still widespread but is believed likely to move into a category of higher threat in the near future if threatening processes continue or begin operating throughout its range.

Table A.3 Conservation categories & definitions for Priority Ecological Communities as listed by the Department of Parks and Wildlife

Category	Description
Priority 1	Poorly known ecological communities. Ecological communities that are known from very few occurrences with a very restricted distribution (generally ≤5 occurrences or a total area of ≤100 ha). Occurrences are believed to be under threat either due to limited extent, or being on lands under immediate threat (e.g. within agricultural or pastoral lands, urban areas, active mineral leases) or for which current threats exist. May include communities with occurrences on protected lands. Communities may be included if they are comparatively well-known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range.
Priority 2	Poorly known ecological communities. Communities that are known from few occurrences with a restricted distribution (generally ≤10 occurrences or a total area of ≤200 ha). At least some occurrences are not believed to be under immediate threat of destruction or degradation. Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under threat from known threatening processes.
Priority 3	Poorly known ecological communities. (i) Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or: (ii) communities known from a few widespread occurrences, which are either large or with significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or; (iii) communities made up of large, and/or widespread occurrences, that may or may not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, and inappropriate fire regimes. Communities may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and/or are not well defined, and known threatening processes exist that could affect them.
Priority 4	Ecological communities that are adequately known, rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list. These communities require regular monitoring. (i) Rare. Ecological communities known from few occurrences that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These communities are usually represented on conservation lands. (ii) Near Threatened. Ecological communities that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable. (iii) Ecological communities that have been removed from the list of threatened communities during the past five years.
Priority 5	Conservation Dependent ecological communities. Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

Other significant vegetation

Vegetation may be significant for a range of reasons, other than a statutory listing as a TEC or because the extent is below a threshold level. The EPA (2004a) states that significant vegetation may include vegetation that includes the following:

- Scarcity
- Unusual species
- Novel combinations of species
- A role as a refuge
- A role as a key habitat for Threatened species or large population representing a significant proportion of the local to regional total population of a species
- Being representative of the range of a unit (particularly, a good local and/or regional example of a unit in 'prime' habitat, at the extremes of range, recently discovered range extensions, or isolated outliers of the main range)
- A restricted distribution

This may apply at a number of levels, so the unit may be significant when considered at the fine-scale (intra-locality), intermediate-scale (locality or inter-locality) or broad-scale (local to region).

Conservation significant flora & fauna

Species of significant flora are protected under both Federal and State legislation. Any activities that are deemed to have a significant impact on species that are recognised by the EPBC Act, and/or the WC Act can warrant referral to the DotE and/or the EPA. According to the DPaW (WA Herbarium, 1998–): "Threatened flora are plants which have been assessed as being at risk of extinction. In Western Australia the term Declared Rare Flora (DRF) is applied to Threatened flora due to the laws regarding threatened flora conservation. The WC Act is the primary wildlife conservation legislation in the State and the Minster for the Environment can declare taxa (species, subspecies or variety) as "Rare Flora" if they are considered to be in danger of extinction, rare or otherwise in need of special protection." For the purposes of this report, flora listed by the WC Act as DRF is described as Threatened.

The Federal conservation level of flora and fauna species and their significance status is assessed under the EPBC Act (Table A.4). The significance levels for fauna used in the EPBC Act are those recommended by the International Union for the Conservation of Nature and Natural Resources (IUCN).

The State conservation level of fauna species and their significance status is assessed under the State WC Act (*Wildlife Conservation (Specially Protected Fauna) Notice 2010(2)*). This Act uses a set of Schedules (Table A.4) but also classifies species using some of the IUCN categories. Schedule 3 fauna species are those which are "subject to an agreement between the Government of Australia and the Governments of Japan, China and the Republic of Korea relating to the protection of migratory birds, are declared to be fauna that is in need of special protection".

In Western Australia, the DPaW also maintains a list of Priority listed flora species. Conservation codes for Priority species are assigned by the DPaW to define the level of conservation significance (Table A.4). Priority species are not currently protected under the WC Act.

For the purposes of this assessment, all species listed under the EPBC Act, WC Act and DPaW Priority species are considered conservation significant.

Table A.4 Conservation categories & definitions for *Environment Protection and Biodiversity Conservation Act 1999* listed flora & fauna species

Conservation Category	Definition
Extinct	Taxa not definitely located in the wild during the past 50 years
Extinct in the Wild	Taxa known to survive only in captivity
Critically Endangered	Taxa facing an extremely high risk of extinction in the wild in the immediate future
Endangered	Taxa facing a very high risk of extinction in the wild in the near future
Vulnerable	Taxa facing a high risk of extinction in the wild in the medium-term
Near Threatened	Taxa that risk becoming Vulnerable in the wild
Conservation Dependent	Taxa whose survival depends upon ongoing conservation measures. Without these measures, a conservation dependent taxon would be classified as Vulnerable or more severely threatened.
Data Deficient (Insufficiently Known)	Taxa suspected of being Rare, Vulnerable or Endangered, but whose true status cannot be determined without more information.
Least Concern	Taxa that are not considered Threatened

Table A.5 Conservation codes and descriptions for Western Australian flora & fauna

Code	Conservation Category	Description
Wildlife Conservation Act 1950		
T	Schedule 1 under the WC Act	Threatened Fauna (Fauna that is rare or is likely to become extinct) Threatened Flora (Declared Rare Flora – Extant) Taxa that have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such. 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. VU: Vulnerable – considered to be facing a high risk of extinction in the wild.
X	Schedule 2 under the WC Act	Presumed Extinct Fauna Presumed Extinct Flora (Declared Rare Flora – Extinct) Taxa which have been adequately searched for and there is no reasonable doubt that the last individual has died, and have been gazetted as such.
IA	Schedule 3 under the WC Act	Birds protected under an international agreement. Birds that are subject to an agreement between governments of Australia and Japan relating to the protection of migratory birds and birds in danger of extinction.

Code	Conservation Category	Description
S	Schedule 4 under the WC Act	Other specially protected fauna. Fauna that is in need of special protection, otherwise than for the reasons mentioned in the above schedules.
DPaW Priority Listed		
1	Priority One: Poorly-known taxa	Taxa that are known from one or a few collections or sight records (generally less than five), all on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, Shire, Westrail and Main Roads WA road, gravel and soil reserves, and active mineral leases and under threat of habitat destruction or degradation. Taxa may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes.
2	Priority Two: Poorly-known taxa	Taxa that are known from one or a few collections or sight records, some of which are on lands not under imminent threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant Crown land, water reserves, etc. Taxa may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes.
3	Priority Three: Poorly-known taxa	Taxa that are known from collections or sight records from several localities not under imminent threat, or from few but widespread localities with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Taxa may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and known threatening processes exist that could affect them.
4	Priority Four: Rare, Near Threatened and other taxa in need of monitoring	(a) Rare. Taxa that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands. (b) Near Threatened. Taxa that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable. (c) Taxa that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.
5	Priority 5: Conservation Dependent taxa	Taxa that are not threatened but are subject to a specific conservation program, the cessation of which would result in the taxon becoming threatened within five years.

Migratory species listed under the EPBC Act

The EPBC Act also protects land and migratory species that are listed under International Agreements. The list of migratory species established under section 209 of the EPBC Act comprises:

- Migratory species which are native to Australia and are included in the appendices to the Bonn Convention (Convention on the Conservation of Migratory Species of Wild Animals Appendices I and II)
- Migratory species included in annexes established under the Japan-Australia Migratory Bird Agreement (JAMBA) and the China–Australia Migratory Bird Agreement (CAMBA)
- Native, migratory species identified in a list established under, or an instrument made under, an international agreement approved by the Minister, such as the republic of Korea–Australia Migratory Bird Agreement (ROKAMBA)

Other significant flora & fauna

Flora species, subspecies, varieties, hybrids and ecotypes may be significant for a range of reasons, other than as Threatened (Declared Rare) Flora or Priority Flora. The EPA (2004a) states that significant flora may include taxa that have:

- A keystone role in a particular habitat for threatened species or supporting large populations representing a significant proportion of the local regional population of a species
- Relic status
- Anomalous features that indicate a potential new discovery
- Being representative of the range of a species (particularly, at the extremes of range, recently discovered range extensions, or isolated outliers of the main range)
- The presence of restricted subspecies, varieties, or naturally occurring hybrids
- Locally endemic restricted distribution
- Being poorly reserved

The application of the degree of significance may apply at a range of scales.

Introduced plants (weeds)

Declared Pests

The Department of Agriculture and Food Western Australia (DAFWA) maintains a list of Declared Pests for Western Australia that have been declared under the BAM Act. If a Pest is declared for the whole of the State or for particular Local Government Areas, all landholders are obliged to comply with the specific category of control. Declared Pests are gazetted under categories, which define the action required. The category may apply to the whole of the State, districts, individual properties or even paddocks. Categories of control are defined in Table B.6. Among the factors considered in categorising Declared Pests are:

- The impact of the plant on individuals, agricultural production and the community in general
- Whether it is already established in the area
- The feasibility and cost of possible control measures

Table A.6 Department of Agriculture and Food (Western Australia) Categories for Declared Pests under the Biosecurity and Agriculture Management Act 2007

Control Class Code	Description
C1 (Exclusion)	Pests will be assigned to this category if they are not established in Western Australia and control measures are to be taken, including border checks, in order to prevent them entering and establishing in the State.
C2 (Eradication)	Pests will be assigned to this category if they are present in Western Australia in low enough numbers or in sufficiently limited areas that their eradication is still a possibility.
C3 (Management)	Pests will be assigned to this category if they are established in Western Australia but it is feasible, or desirable, to manage them in order to limit their damage. Control measures can prevent a C3 pest from increasing in population size or density or moving from an area in which it is established into an area which currently is free of that pest.

Weeds of National Significance

The spread of weeds across a range of land uses or ecosystems is important in the context of socio-economic and environmental values. The assessment of Weeds of National Significance (WoNS) is based on four major criteria:

- Invasiveness
- Impacts
- Potential for spread
- Socio-economic and environmental values

Australian state and territory governments have identified thirty two Weeds of National Significance (WoNS); a list of 20 WoNS was endorsed in 1999 and a further 12 were added in 2012 (Australian Government, 2012).

Environmental weeds

“Environmental weeds are plants that establish themselves in natural ecosystems (marine, aquatic and terrestrial) and proceed to modify natural processes, usually adversely, resulting in the decline of the communities they invade” (CALM, 1999). The Environmental Weed Strategy for Western Australia (EWSWA) was published in 1999. This document provides direction and an approach to tackling environmental weeds in WA (CALM, 1999). Following on from this strategy (in 2008), in an effort to address invasive weeds and implement an integrated approach to weed management on DPaW-managed lands in WA, the Weed Prioritisation Process was developed (DPaW, 2013). A series of workshops were held in each of the nine DPaW regions with the purpose of scoring all weeds which occurred in each of the DPaW regions according to the following key attributes (DPaW, 2013):

- Potential distribution and impact
- Invasiveness
- Current distribution
- Feasibility of control
- Weed management ability
- Weed risk

This process resulted in the following five ratings for each weed species (DPaW, 2013):

- Very high (VH)
- High (H)
- Medium (M)
- Low (L)
- Negligible (N)

The suggested management actions for each species range from no action required (the weed species ranking is as low as to not warrant any investment in regional strategic management actions), through targeted control to reduce infestation or spread, to species requiring state-wide eradication (DPaW, 2013). A total of 1350 weeds were rated through this process as high, moderate, mild or low, with 34 weed species being rated as high (DPaW, 2013).

The prioritisation for individual weeds within a DPaW region should be treated as a guide and does not diminish any other requirements of land managers or developers e.g. Declared Plants requirements of the BAM Act or Ministerial requirements under Part IV of the EP Act (DPaW, 2013).

Reserves and Conservation Areas

DPaW manages lands and waters throughout Western Australia to conserve ecosystems and species, and to provide for recreation and appreciation of the natural environment. DPaW managed lands and waters include national parks, conservation parks and reserves, marine parks and reserves, regional parks, nature reserves, State forest and timber reserves. DPaW managed conservation estate, is vested with the Conservation Commission of Western Australia. Access to, or through, some areas of DPaW managed lands may require a permit or could be restricted due to management activities. Proposed land use changes and development proposals that abut DPaW managed lands will generally be referred to DPaW throughout the assessment process.

Contaminated Sites

Contaminated sites in Western Australia are regulated under the *Contaminated Sites Act 2003*. Under this Act contaminated sites must be reported to the DER, investigated and, if necessary, remediated. The Contaminated Sites Database records information on sites classified as:

- contaminated - remediation required
- contaminated - restricted use
- remediated for restricted use.

The Contaminated Sites Database holds information on all other sites reported to DER, including sites awaiting classification. Additional contaminated sites may be present in the area but have not been reported to the DER and therefore may not be on the register.

Heritage

Federal Heritage

At the Federal level, protection of significant places is provided under the EPBC Act; the *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* and the *Historic Shipwrecks Act 1976*.

The Australian Heritage Database contains information about Australian places that have natural, historic and indigenous value. This database contains information on heritage matters of national environmental significance, which are protected under the EPBC Act. This database includes places listed on the following databases:

- World Heritage List – a list of places that are important to all the peoples of the world. World Heritage sites are recognised under the World Heritage Convention as being of international significance because of their outstanding natural and/or cultural values
- National Heritage List – comprises natural, historic and indigenous places that are of outstanding heritage value to the Australian nation.

State Non-Aboriginal Heritage

The Heritage Council of Western Australia is a state government agency responsible for the management of the historic resource. The *Heritage of Western Australia Act 1990* makes a provision for the preservation of places of historic significance. This significance is based on aesthetic, social and scientific principles. Under the Act, a Heritage Place refers only to a building, a definable piece of land and contents relevant to the building.

A heritage agreement is formed between the Minister and the owner of a heritage place based on a voluntary agreement but this is then enforced by the Heritage Council on successive owners and mortgages, government departments, municipal councils and developers. Protection from inappropriate development of a heritage place is granted under the *Heritage of Western Australia Act 1990*, which requires all applications to modify a place to be referred to the Heritage Council. This protection is bestowed to buildings registered on the interim or permanent lists under sections 50 and 51 of the Act.

The State Heritage Office keeps a heritage register “InHerit” that contains comprehensive information about cultural heritage places listed in the State Register of Heritage Places, local government inventories and other lists, the Australian Government's heritage list, and other non-government lists and surveys.

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Appendix B – Methodology

Methodology

Desktop assessment

A desktop assessment was carried out prior to the commencement of the field survey in order to identify key environmental constraints known from, or predicted to occur within, the Study area. The desktop assessment included the following:

- A review of previous Main Roads projects undertaken by GHD along or in the vicinity of the Study area. The database and GIS information from these projects (e.g. previously mapped vegetation types and condition) were incorporated into this study. This information, in combination with aerial photograph interpretation, was used to target the flora and fauna survey effort.
- A description of the existing environment including physical and bio-physical aspects.
- A search of the Department of Parks and Wildlife (DPaW) threatened species and communities database for flora, fauna and ecological communities.
- A review of the following environmental aspects:
  - Acid sulfate soils
  - Air quality
  - Contamination
  - Dust
  - Environmentally sensitive areas
  - Geology, topography and soils
  - Hydrology
  - Hazardous substances
  - Heritage (non-indigenous)
  - Land systems
  - Land vesting
  - Matters of National Environmental Significance
  - Native vegetation including Beard associations, representativeness, condition, riparian vegetation, threatened flora and threatened ecological communities
  - Fauna
  - Reserves and conservation areas
  - Noise
  - Vibration
  - Topsoil management
  - Weeds
  - Disease and pathogens
  - Visual amenity
  - Wetlands

Vegetation and flora survey

GHD ecologists conducted a Level 2 vegetation and flora (EPA 2004a) survey of the Survey Area from 28 October to 5 November 2013. The survey was undertaken in order to identify and describe the dominant vegetation units, assess vegetation condition and identify and record vascular flora taxa present at the time of survey. Additionally, opportunistic searching for conservation significant or other significant ecological communities and flora taxa was undertaken.

Data collection

Field survey methods involved a combination of sampling using quadrats and transects, located in identified vegetation units, and traversing the Survey Area by foot and vehicle. A total of 59 quadrats and 27 transects were described throughout the Survey Area.

Where possible, a minimum of two quadrats were located within each identified vegetation unit, with quadrats 50 x 50 m in size (area of 2,500 m^2). However, there were a number of vegetation units that were restricted in size or location and only one quadrat could be placed in these areas. Field data at each quadrat was recorded on a pro-forma data sheet and included the parameters detailed in Table B.1.

Table B.1 Quadrat data collected during the survey

Aspect	Measurement
Collection attributes	Personnel/observers, date, quadrat ID, quadrat dimensions, photograph of quadrat
Location	Brief locality description, coordinates recorded in GDA94 datum using a hand-held Global Positioning System (GPS) tool to accuracy approximately ± 10 m
Physical features	Landform, site drainage, soil colour, soil type, percentage surface cover by: rocks, logs, twigs/branches, leaf and bare ground
Vegetation condition	Vegetation condition was assessed using the condition rating scale developed by Keighery (1994)
Disturbance	Nature of disturbances (e.g. clearing, cultivation, infrastructure, weed presence, flood, animal), grazing type and intensity, fire frequency and intensity
Flora	List of dominant flora for each identified stratum, list of all species within the quadrat including stratum, average height and cover (using a modified Braun-Blanquet scale)

Transects were also surveyed throughout the Survey Area. Transects were linear to semi-linear traverses undertaken to record vegetation and flora along environmental gradients or within vegetation units. Transects varied in size depending on the area of interest.

A flora inventory was compiled from taxa listed in described quadrats, transects, rapid assessment points, and from opportunistic floristic records throughout the Survey Area.

The survey methodology employed by GHD was consistent with the Environmental Protection Authority (EPA) Guidance Statement No. 51 Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia (EPA 2004a) and Terrestrial Biological Surveys as an Element of Biodiversity Protection, Position Statement No. 3 (EPA 2002).

Vegetation units

Vegetation units were identified and boundaries delineated using a combination of aerial photography, topographical features, previous mapping (Beard 1974) and field data/observations.

Vegetation units were described based on structure, dominant taxa and cover characteristics as defined by quadrat data and field observations. The unit descriptions follow the National Vegetation Information System (NVIS) and are consistent with NVIS Level V (Association) (ESCAVI 2003). At this level up to three taxa per stratum are used to describe the association (ESCAVI 2003)..

Vegetation mapping has been undertaken at a scale of 1:50,000; this is considered a suitable scale for this Project.

Vegetation condition

The vegetation condition of the Survey Area was assessed using the vegetation condition rating scale developed by Keighery (1994) that recognises the intactness of vegetation, which is defined by the following:

- Completeness of structural levels.
- Extent of weed invasion.
- Historical disturbance from tracks and other clearing or dumping.
- The potential for natural or assisted regeneration.

The scale, therefore, consists of six rating levels as outlined below in Table .

Table B.2 Vegetation condition rating scale (Keighery 1994)

Condition Rating	Vegetation Condition	Description
1	Pristine or Nearly so	No obvious signs of disturbance.
2	Excellent	Vegetation structure intact, disturbance affecting individual species, and weeds are non-aggressive species.
3	Very Good	Vegetation structure altered, obvious signs of disturbance.
4	Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances retains basic vegetation structure or ability to regenerate it.
5	Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not in a state approaching good condition without intensive management.
6	Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost without native species.

Flora identification and nomenclature

Species that were well known to the survey ecologists were identified in the field, while species that could not be identified in the field were collected and assigned a unique number to facilitate tracking. Plant species were identified by the use of local and regional flora keys and by comparison with the named species held at the Western Australian Herbarium (WA Herbarium).

The conservation status of all recorded flora was compared against the current lists available on *FloraBase* (WA Herbarium 1998–) and the EPBC Act Threatened species database provided by DotE (2013b).

Nomenclature used in the report follows that used by the WA Herbarium as reported on *FloraBase* (WA Herbarium 1998–). With the exception of Mulga group taxa which follow Maslin and Reid (2012).

Conservation significant flora

Targeted and opportunistic searches for conservation significant flora taxa were undertaken within the Survey Area. When conservation significant taxa were found, the location of each individual or the population boundaries were recorded by GPS and the number of individuals or estimate of population size recorded. Where conservation significant taxa were present a search was undertaken in adjacent areas to quantify the population extent.

When any conservation significant taxa were found, the following data was collected:

- Location and frequency information.
- Details on the habit and habitat.
- A photograph of the plant(s) *in situ.*

Fauna survey

Survey details and timing

Two GHD ecologists completed a fauna survey of the Survey Area from 6-13 November 2013. This survey was undertaken immediately after the completion of the vegetation and flora surveys. The fauna survey involved targeted species-specific survey methods, aimed at identifying and mapping the presence of conservation significant fauna species and suitable habitat, in order to inform a likelihood of occurrence assessment for each of these species. In addition to the targeted survey, GHD ecologists also undertook a Level 1 fauna survey (reconnaissance survey) of the Survey Area.

The methodology used to undertake the fauna assessment included:

- Opportunistic searches across all habitat types within the Survey Area. This ensured the maximum suite of species potentially occurring at the Survey Area was observed. The survey involved searching through microhabitats including turning over logs or rocks, turning over leaf litter and examining hollow logs.
- Opportunistic visual and aural surveys. This accounted for many bird species potentially utilising the Study area.
- Searching for tracks, scats, bones, diggings and feeding areas for both native and feral fauna.
- Habitat assessments.
- Nocturnal surveys undertaken throughout the Survey Area by vehicle.

Targeted surveys for conservation significant fauna

Targeted specific methods were used to sample for each of the EPBC-listed conservation significant fauna species listed in Table B.3 within the Survey Area.

Table B.3 Targeted fauna survey methods

Species	Method	Description
Bilby (*Macrotis lagotis*)	Active searches for diggings and burrows	Intensive searches in areas where suitable habitat was identified. These searches are referred to as Bilby Search Areas (BSAs), and are recommended as the preferred method to survey for the species (Southgate *et al* 2005; Southgate and Moseby 2008; Southgate 2012,). A total of 28 BSA's were undertaken in the Survey Area (Figure 9). Each BSA was approximately 50 m x 400 m (2 ha) in size and were intensively searched for burrows, prints and scats. All observations were recorded via GPS along with the approximate age of the activity.
	Remote camera traps (surveillance cameras)	24 remote camera traps were deployed throughout the Survey Area, including six in spinifex hummock grasslands, four in *Acacia* shrubland habitats and one on the Bubble Creek floodplain (Figure 9).
Crest-tailed Mulgara (*Dasycercus cristicauda*) and Brush-tailed Mulgara (*Dasycercus blythi*)	Trapping	40 Elliot traps were deployed in spinifex grassland habitats (Four quadrats of 10 Elliot s at 10 metre intervals) and sampled for between six to seven nights (Figure 9). Each quadrat was placed in areas where Mulgara evidence was present i.e. scats, tracks and burrows.
	Targeted searches	Targeted searches for Brush-tailed Mulgara in suitable spinifex hummock grassland habitat and targeted searches for Crest-tailed Mulgara in suitable sand dune habitat within the Survey Area.
	Remote camera traps (surveillance cameras)	24 remote camera traps were deployed throughout the Survey Area, including six in spinifex plain habitats (Figure 9).
Long-tailed Dunnart (*Sminthopsis longicaudata*)	Trapping	20 Elliot traps were deployed at Mt Russell (Two quadrats of 10 Elliot's at 10 metre intervals) and sampled for five nights.
	Targeted searches	Targeted searches for Long-tailed Dunnart in suitable rocky habitat within the Survey Area.
	Remote camera traps (surveillance cameras)	24 remote camera traps were deployed throughout the Survey Area, including seven in rocky habitats (Figure 9).
Malleefowl (*Leipoa ocellata*)	Active searches for individuals, diggings, burrows and mounds	Active searches throughout suitable dense *Acacia* shrubland habitat for individuals, scratchings, diggings, tracks and mounds.
	Remote camera traps (surveillance cameras)	24 remote camera traps were deployed throughout the Survey Area, including five in *Acacia* shrubland habitats (Figure 9).
Northern Marsupial Mole (*Notoryctes caurinus*)	Habitat assessment	Targeted habitat searches to determine the extent of potentially suitable dune habitat within the Survey Area. There is no proven (or accepted) survey technique to detect the Northern Marsupial Mole, however visual inspection of dune habitat was undertaken looking for signs of use.

Species	Method	Description
Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*)	Bat detector	One Songmeter SM2 bat + unit was deployed at six locations for one night each within a variety of habitats to record the echolocation calls of this species. This provided roughly one songmeter sampling point every 25 km.
Great Desert Skink (*Liopholis kintorei*)	Active searches for individuals and latrine sites	Active searches for individuals and latrine sites within suitable habitats in the Survey Area. If latrine sites are identified, camera traps will be deployed to identify species use.
Western Spiny-tailed Skink (*Egernia stokesii badia)*	Active searches for individuals and latrine sites	Active searches for individuals and latrine sites in rocky areas of the Project. If required, remote camera traps will be deployed to identify species use.

Trapping effort

Targeted trapping for each of the above species was undertaken using a combination of Elliot traps, camera traps, a bat detector, active searches and night searches. This targeted trapping included:

- Six Elliot trap lines located within hummock grassland sites across the Survey Area (10 Elliot traps per line, spaced 10 m apart) (Table B.4). In total 370 trap nights were undertaken.
- Songmeter SM2 bat + unit deployed over six nights in different locations (Table B.5).
- Twenty-four remote camera traps (23 Reconyx-Hyperfire and one Scout Guard 550) located within a variety of different habitat types in the Survey Area. In total 155 camera trap nights were undertaken. Each camera trap was baited with universal bait to attract fauna. Camera trap locations and trap effort is shown in Table B.6.

Table B.4 Elliot trap line locations

Site	Location		Nights Open	Elliot Traps	
	Easting	Northing		No.	Total Trap Nights
Site 1	737466	7070992	7	10	70
Site 2	741364	7070262	7	10	70
Site 3	739530	7070810	7	10	70
Site 4	737537	7070546	6	10	60
Site 5	783489	7066109	5	10	50
Site 6	783574	7066123	5	10	50
			Total	**60**	**370**

Table B.5 Songmeter SM2 bat + unit locations

Date	Location	Easting	Northing
7/11/2013	Meekatharra Plain	657527	7058496
8/11/2013	Bubble Creek	805487	7055628
9/11/2013	Mt Russell	783502	7065755
10/11/2013	Mulga/Spinifex Plain	737499	7070505
11/11/2013	Breakaway	698335	7073748
12/11/2013	BIF Hill	675595	7060461

Table B.6 Camera trap locations and survey effort

Camera trap no.	Location Description	Zone	Easting	Northing	Night in	Night out	Nights in use
1	Calcareous outcrop	50	664230	7058543	4/11	9/11	5
2	BIF Hill	50	675432	7060504	6/11	13/11	7
3	Spinifex plain	50	688661	7068292	9/11	13/11	4
4	Dam	50	696929	7073272	1/11	6/11	5
5	Calcareous outcrop	50	698278	7073535	1/11	6/11	5
6	Granite outcrop	50	698230	7073872	7/11	13/11	6
7	Gorge (near creekline)	50	701147	7073818	1/11	6/11	5
8	Creekline	50	705200	7074760	1/11	6/11	5
9	Sand dune	50	705651	7075176	4/11	13/11	9
10	Small BIF Hill	50	718346	7075308	2/11	13/11	11
11	Thick *Acacia* shrubland	50	730680	7072050	7/11	13/11	6
12	Spinifex plain	50	737685	7070613	7/11	13/11	6
13	Spinifex plain	50	738839	7070464	6/11	13/11	7
14	Spinifex plain - active Mulgara burrow	50	739040	7070503	6/11	13/11	7
15	Spinifex plain	50	739481	7070705	1/11	13/11	12
16	*Acacia* shrubland	50	741390	7070155	6/11	13/11	7
17	*Acacia* shrubland	50	758198	7068463	6/11	13/11	7
18	*Acacia* shrubland	50	758267	7068541	6/11	13/11	7
19	Spinifex plain	50	768623	7067486	9/11	13/11	4
20	Mt Russell	50	783650	7066166	3/11	13/11	10
21	Mulga grove	50	789487	7062088	8/11	13/11	5
22	Red Gum woodland near Bubble Creek	51	202072	7058070	8/11	13/11	5
23	Bubble Creek floodplain	51	207295	7055871	8/11	13/11	5
24	Bubble Creek	51	207849	7055990	3/11	8/11	5
						Total	**155**

Permits and ethics

A Regulation 17 Licence to Take Fauna for Scientific Purposes was obtained from DPaW prior to undertaking the fauna surveys (Licence Number: SF009533).

The fauna surveys (specifically trapping and animal handling) were undertaken in accordance with Standard Operating Procedures (SOPs) which were required to be followed under the conditions of GHD's fauna trapping permit. At the time of survey, compliance with these SOPs was accepted by DPaW as evidence of ethical treatment of animals:

- SOP No. 9.1 Elliott traps for live capture of terrestrial vertebrates (DEC 2009a).
- SOP No. 9.6 Hand capture of wildlife (DEC 2009b).
- SOP No. 10.1 Animal handling/restraint using soft containment (DEC 2009c).
- SOP No. 10.2 Hand restraint of wildlife (DEC 2009d).
- SOP No. 14.2 First Aid for animals (DEC 2009e).

Data collection

The survey methodology GHD employed was consistent with the EPA Guidance Statement No. 56, *Terrestrial Fauna and Vegetation Surveys for Environmental Impact Assessment in Western Australia* (EPA 2004b) and DPaW and EPA's *Technical Guide Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment* (EPA and DEC 2010).

Fauna identification and nomenclature

Nomenclature used in this report follows that used by the WA Museum as reported on *NatureMap* (DPaW 2007–). This nomenclature is deemed the most up-to-date species information for Western Australia groups: Reptiles, Amphibians, Invertebrates and Mammals. All Aves nomenclature follows Christidis and Boles (2008). Other reference materials used are presented in Table B.7.

Table B.7 Fauna references

Fauna Group	Field Guide
Mammals	Menkhorst and Knight (2004), Van Dyck and Strahan (2008), Van Dyck *et al.* (2013)
Bats	Churchill (2008), Menkhorst and Knight (2010), Van Dyck *et al.* (2013)
Birds	Morcombe (2004), Pizzey and Knight (2012)
Geckos	Wilson and Swan (2013)
Skinks	Storr *et al*. (1999), Wilson and Swan (2013)
Dragons	Wilson and Swan (2013)
Varanids	Wilson and Swan (2013)
Legless Lizards	Wilson and Swan (2013)
Snakes	Storr *et al*. (2002), Wilson and Swan (2013)
Amphibians	Tyler and Doughty (2009)

Survey limitations

Guidance Statement No. 51 and No. 56 (EPA 2004a, 2004b) states that flora and fauna survey reports for environmental impact assessment in Western Australia should contain a section describing the limitations of the survey methods used. The limitations and constraints associated with the vegetation, flora and fauna field surveys are discussed in Table B.8.

Table B.8 Field survey constraints and limitations

Limitation	Constraint	Impact on Survey Outcomes
Scope (what faunal groups were sampled)	Nil	Vascular flora taxa were sampled during the survey. Non-vascular flora taxa were not assessed. Terrestrial vertebrate fauna were sampled during the survey. Invertebrate and aquatic fauna were not assessed.
Proportion of flora/fauna identified, recorded and/or collected	Minor	The survey was undertaken in November 2013 (end of the Spring season). The proportion of flora collected and identified was considered high; however, many ephemeral and grass species were unable to be confidently identified to species due to the absence of flowering parts and/or fruiting bodies. Some flora species, such as annuals, are only available for collection at certain times of the year and others are only identifiable at certain times (such as when they are flowering). Additionally, climatic and stochastic events (such as fire) may affect the presence of plant species. Species that have a very low abundance in the area are more difficult to locate, due to the above factors. Complete flora and fauna surveys can require multiple surveys, at different times of year, and over a period of a number of years, to enable observation of all species present. The targeted fauna survey was undertaken in early November 2013 and included specific targeted methods as well as a general reconnaissance survey. The fauna assessment therefore only sampled the specific conservation significant outlined in Table B.2, as well as species those species that can be easily seen, heard or have distinctive signs, such as tracks, scats, diggings etc. Many cryptic and nocturnal species would not have been identified during the survey and seasonal variation within species often requires targeted surveys at a particular time of the year. Of the fauna species recorded during the survey, the majority of species were identified to a species level. Evidence of Mulgara (*Dasycercus* sp.) was recorded during the field survey, which could definitively be classified as either *Dasycercus blythi* or *Dasycercus cristicauda*. Based on recent work by Woolley *et al*. (2013), it is likely that this evidence is of the Brush-tailed Mulgara (*Dasycercus blythi*) (see discussion in section 2.8.6. The fauna assessment was aimed at identifying habitat types and terrestrial vertebrate fauna utilising the Survey Area. No sampling for invertebrates or aquatic species occurred. The information available on the identification, distribution and conservation status of invertebrates is generally less extensive than that of vertebrate species.
Sources of information and availability of contextual information	Minor	Adequate information is available for the Survey Area, this includes: • Regional biogeography (Desmond *et al*. 2001; McKenzie *et al*. 2002; Cowan 2001) • Broad scale (1:1,000,000) mapping by Beard (1974) and Shepherd *et al.* (2002) • Land systems (Mabbutt *et al.* 1963) • Previous reports including GHD 2011; 2013 • Birdata Australia

Limitation	Constraint	Impact on Survey Outcomes
Proportion of the task achieved and further work which might be needed	Minor	Fauna assessments that capture the full spectrum of species in an area often include numerous surveys over different seasons over a number of years. This assessment included one fauna surveys over one season and although meets the guideline requirements for terrestrial surveys may not identify all species present or that utilise the Survey Area. Further targeted surveys for Mulgara may be required, in order to determine the extent of the species occurrence within the proposed Impact Area.
Flora determination	Nil	Flora determination was undertaken by GHD ecologists in field and at the Western Australian Herbarium. All potential Priority flora taxa were submitted to the WA Herbarium for identification and/or verification (Accession 5735)). The taxonomy and conservation status of the Western Australian flora is dynamic. This report was prepared with reliance on taxonomy and conservation current at the time issuing, but it should be noted this may change.
Timing, weather, season, cycle	Minor	The field survey was conducted during the spring, on 6-13 November 2013. In the three months prior to the survey (Aug-Oct), Meekatharra Airport (station number 7045, BoM 2013a) recorded a total of 1.2 mm of rainfall. This total is significantly less than the long term average for the same period (Aug-Oct; 22 mm) (BoM, 2013a). The weather conditions at Meekatharra Airport during the field survey included: • Daily maximum temperature ranging from 32.0 to 38.7 °C. • Daily minimum temperature ranging from 18.7 to 22.8 °C • Daily rainfall 0 mm. In the three months prior to the survey (Aug-Oct), Wiluna (station number 13012, BoM 2013b) recorded a total of 54.4 mm of rainfall. This total is approximately double the long term average for the same period (Jun-Aug; 22.1 mm) (BoM, 2013b). The weather conditions at Wiluna (when recorded) during the field survey included: • Daily maximum temperature ranging from 30.4 to 42.7 °C. • Daily minimum temperature ranging from 15.8 to 21.8 °C • Daily rainfall 0 mm. The weather conditions recorded during the survey period were considered likely to have impacted upon the fauna survey. The hot and dry conditions are likely to have reduced species activity and the number of species recorded during the fauna survey. Additionally some species observed were in very poor condition in particular skinks which had hip bone perfusion, evidence of a harsh period.
Disturbances (fire, flood, accidental human intervention etc.)	Minor	There were two areas where roadworks were being undertaken during the November survey (five km sections). These roadworks may have interfered with the fauna species that were present during the field survey.

Limitation	Constraint	Impact on Survey Outcomes
Resources	Nil	Adequate resources were employed during the survey. A total of 28 person days were spent undertaking the vegetation and flora survey.
Remoteness and/or access problems	Minor	There were two areas where roadworks were being undertaken during the November survey (five km sections). Access to the Survey Area was restricted in the areas surrounding these roadworks.
Experience levels	Nil	The ecologists who executed the survey were practitioners suitably qualified in their respective fields.

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Appendix C – Desktop searches

EPBC Act Protected Matters Search

***NatureMap* Flora**

***NatureMap* Fauna**

Australian Government

Department of Sustainability, Environment, Water, Population and Communities

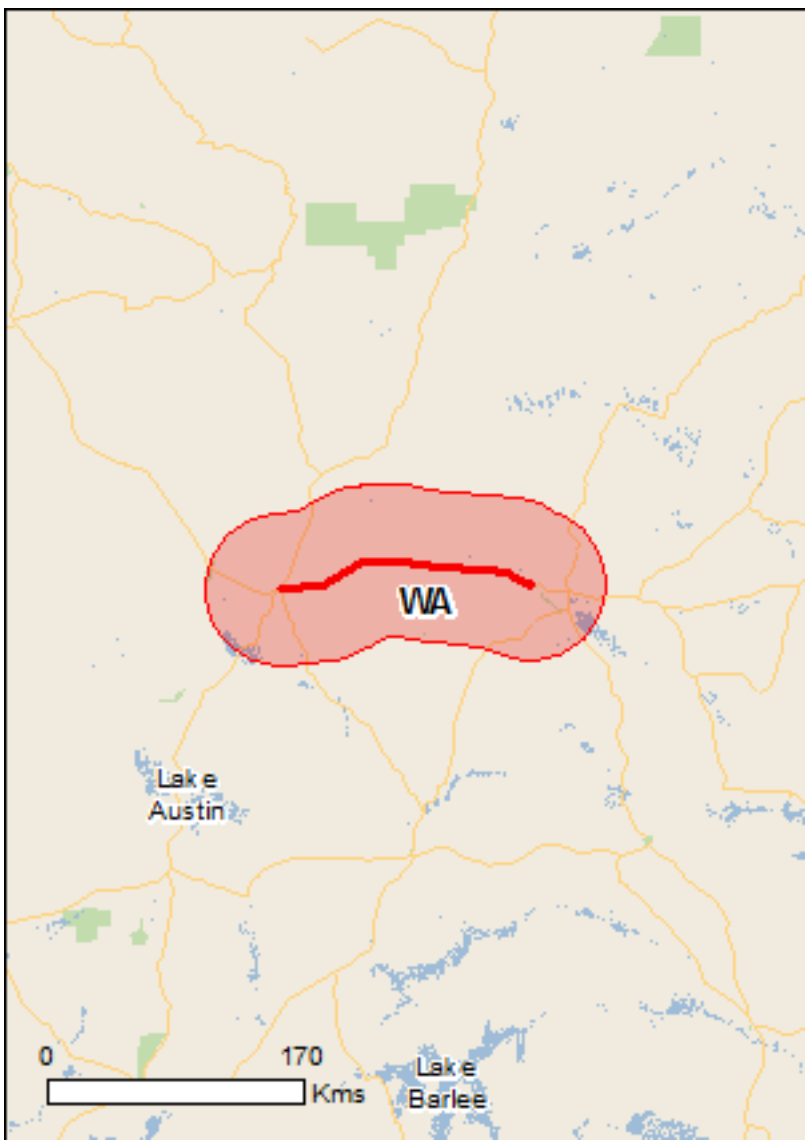
EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

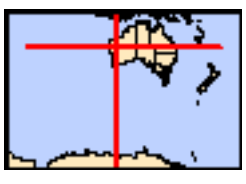
Report created: 17/10/13 12:48:37



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates

Buffer: 50.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Areas:	None
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	7
Listed Migratory Species:	4

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place and the heritage values of a place on the Register of the National Estate.

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	1
Commonwealth Heritage Places:	None
Listed Marine Species:	4
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Commonwealth Reserves Marine	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

Place on the RNE:	2
State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	11
Nationally Important Wetlands:	1
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Species		[Resource Information]
Name	Status	Type of Presence
Birds		
Acanthiza iredalei iredalei		
Slender-billed Thornbill (western) [25967]	Vulnerable	Species or species habitat known to occur within area
Polytelis alexandrae		
Princess Parrot, Alexandra's Parrot [758]	Vulnerable	Species or species habitat may occur within area
Mammals		
Notoryctes caurinus		
Karkarratul, Northern Marsupial Mole [295]	Endangered	Species or species habitat likely to occur within area
Rhinonicteris aurantia (Pilbara form)		
Pilbara Leaf-nosed Bat [82790]	Vulnerable	Species or species habitat likely to occur within area
Other		
Idiosoma nigrum		
Shield-backed Trapdoor Spider, Black Rugose Trapdoor Spider [66798]	Vulnerable	Species or species habitat likely to occur within area
Plants		
Pityrodia augustensis		
Mt Augustus Foxglove [4962]	Vulnerable	Species or species habitat likely to occur within area
Reptiles		
Liopholis kintorei		
Great Desert Skink, Tjakura, Warrarna, Mulyamiji [83160]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Migratory Marine Birds		

Name	Threatened	Type of Presence
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Merops ornatus		
Rainbow Bee-eater [670]		Species or species habitat may occur within area
Migratory Wetlands Species		
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat likely to occur within area
Charadrius veredus		
Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Commonwealth Land -

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat likely to occur within area
Charadrius veredus		
Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Merops ornatus		
Rainbow Bee-eater [670]		Species or species habitat may occur within area

Extra Information

Places on the RNE [Resource Information]

Note that not all Indigenous sites may be listed.

Name	State	Status
Historic		
Canning Stock Route (former)	WA	Indicative Place
Old Courthouse	WA	Registered

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Mammals		
Camelus dromedarius Dromedary, Camel [7]		Species or species habitat likely to occur within area
Capra hircus Goat [2]		Species or species habitat likely to occur within area
Equus asinus Donkey, Ass [4]		Species or species habitat likely to occur within area
Equus caballus Horse [5]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Carrichtera annua Ward's Weed [9511]		Species or species habitat may occur within area
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat likely to occur within area

Nationally Important Wetlands [Resource Information]

Name	State
Lake Annean (Lake Nannine)	WA

Coordinates

-26.588466 118.511897,-26.568816 118.761836,-26.544248 118.814021,-26.441005 118.992549,-26.433627 119.047481,-26.433627 119.223262,-26.470512 119.451228,-26.487721 119.72314,-26.495096 119.849483,-26.531962 119.904414,-26.561446 119.992305,-26.558989 119.992305

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World Heritage and Register of National Estate properties, Wetlands of International Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under 'type of presence'. For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Department of Environment, Climate Change and Water, New South Wales
-Department of Sustainability and Environment, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment and Natural Resources, South Australia
-Parks and Wildlife Service NT, NT Dept of Natural Resources, Environment and the Arts
-Environmental and Resource Management, Queensland
-Department of Environment and Conservation, Western Australia
-Department of the Environment, Climate Change, Energy and Water
-Birds Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-SA Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Atherton and Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
-State Forests of NSW
-Geoscience Australia
-CSIRO
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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Naturemap Flora Search combined 50 km buffer 17/10/13

Name ID	Species Name	Naturalised	Conservation Code	Endemic To Query Area
4889	Abutilon cryptopetalum			
4902	Abutilon oxycarpum (Flannel Weed)			
43020	Abutilon oxycarpum subsp. Prostrate (A.A. Mitchell PRP 1266)			
3194	Acacia abrupta			
16159	Acacia acanthoclada subsp. acanthoclada			
3217	Acacia aneura (Mulga Wanari)			
37260	Acacia aptaneura			
3232	Acacia ayersiana			
14622	Acacia balsamea			
3248	Acacia burkittii (Sandhill Wattle)			
36417	Acacia caesaneura			
3273	Acacia craspedocarpa (Hop Mulga)			
3280	Acacia cuspidifolia (Bohemia)			
15280	Acacia cuthbertsonii subsp. cuthbertsonii			
15279	Acacia cuthbertsonii subsp. linearis			
32118	Acacia effusifolia			
3330	Acacia exocarpoides			
36781	Acacia fuscaneura			
3355	Acacia grasbyi (Miniritchie)			
3364	Acacia helmsiana			
36418	Acacia incurvaneura			
3392	Acacia jamesiana			
3393	Acacia jennerae			
3399	Acacia kempeana (Witchetty Bush Ilykuwara)			
3419	Acacia ligulata (Umbrella Bush Watarka)			
3426	Acacia longispinea			
37240	Acacia macraneura			
36416	Acacia mulganeura			
3452	Acacia murrayana (Sandplain Wattle)			
3463	Acacia nyssophylla			
3473	Acacia oswaldii (Miljee Nelia)			
3475	Acacia pachyacra			
15724	Acacia paraneura			
3500	Acacia pruinocarpa (Gidgee)			
36800	Acacia pteraneura			
29015	Acacia pyrifolia var. pyrifolia			
3507	Acacia quadrimarginea			
19483	Acacia ramulosa var. linophylla			
19499	Acacia ramulosa var. ramulosa			
3519	Acacia rhodophloia			
42600	Acacia salicina			
13077	Acacia sclerosperma subsp. glaucescens		P3	
13078	Acacia sclerosperma subsp. sclerosperma			
3544	Acacia sibilans			
8949	Acacia sibirica (Bastard Mulga)			
29114	Acacia sp. Nalgi (N.T. Burbidge 1317)			
18610	Acacia sp. Wiluna (B.R. Maslin 7090)			
14615	Acacia speckii		P4	
3568	Acacia subtessarogona			
13070	Acacia synchronicia			
3577	Acacia tetragonophylla (Kurara Wakalpuka)			
29531	Acacia thoma			
3586	Acacia tysonii			
3595	Acacia victoriae (Bramble Wattle Ngatunpa)			
31511	Acacia victoriae subsp. victoriae			
3598	Acacia wanyu			
15295	Acacia xanthocarpa			
17739	Acetosa vesicaria	Y		
19901	Actinobole oldfieldianum			
7817	Actinobole uliginosum (Flannel Cudweed)			
2646	Aerva javanica (Kapok Bush)	Y		
3680	Aeschynomene indica (Budda Pea)			
36277	Aloe vera var. officinalis	Y		
2647	Alternanthera angustifolia			
19465	Aluta aspera subsp. hesperia			
19470	Aluta maisonneuvei subsp. auriculata			
19469	Aluta maisonneuvei subsp. maisonneuvei			
4907	Alyogyne pinoniana (Sand Hibiscus)			
2656	Amaranthus caudatus (Love Lies Bleeding)	Y		
2666	Amaranthus mitchellii (Boggabri Weed)			
12025	Amphipogon caricinus var. caricinus			

2372	Amyema fitzgeraldii (Pincushion Mistletoe)		
11614	Amyema gibberula var. gibberula		
11191	Amyema gibberula var. tatei		
2374	Amyema hilliana		
2379	Amyema microphylla		
2380	Amyema miquelii (Stalked Mistletoe)		
2382	Amyema nestor		
40910	Androcalva luteiflora (Yellow-flowered Rulingia)		
7832	Angianthus milnei (Cone-spike Angianthus)		
2333	Anthobolus leptomerioides		
17797	Argemone ochroleuca subsp. ochroleuca	Y	
207	Aristida contorta (Bunched Kerosene Grass)		
12063	Aristida holathera var. holathera		
212	Aristida inaequiglumis (Feathertop Threeawn)		
218	Aristida obscura (Brush Threeawn)		
7847	Asteridea chaetopoda		
2451	Atriplex bunburyana (Silver Saltbush)		
2453	Atriplex codonocarpa (Flat-topped Saltbush)		
2461	Atriplex hymenotheca		
2476	Atriplex semilunaris (Annual Saltbush)		
2481	Atriplex vesicaria (Bladder Saltbush)		
17237	Austrostipa elegantissima		
17246	Austrostipa nitida		
17251	Austrostipa scabra		
17255	Austrostipa trichophylla		
14472	Baeckea sp. Melita Station (H. Pringle 2738)		
14473	Baeckea sp. Sandstone (C.A. Gardner s.n. 26 Oct. 1963)		P3
34240	Beyeria lapidicola		P1
7854	Bidens bipinnata (Bipinnate Beggartick)	Y	
2774	Boerhavia repleta		
11167	Bonamia erecta		
242	Brachyachne prostrata		
7870	Brachyscome cheilocarpa		
7871	Brachyscome ciliaris		
11884	Brachyscome ciliaris var. lanuginosa		
7872	Brachyscome ciliocarpa		
7878	Brachyscome iberidifolia		
7881	Brachyscome oncocarpa		
7413	Brunonia australis (Native Cornflower)		
19376	Bryophyllum delagoense	Y	
750	Bulbostylis barbata		
2845	Calandrinia brevipedata (Short-stalked Purslane)		
36500	Calandrinia creethiae		
2853	Calandrinia eremaea (Twining Purslane)		
2859	Calandrinia papillata		
2860	Calandrinia polyandra (Parakeelya)		
2864	Calandrinia ptychosperma		
2865	Calandrinia pumila		
2868	Calandrinia reticulata		
2869	Calandrinia schistorhiza		
19455	Calandrinia sp. Bungalbin (G.J. Keighery & N. Gibson 1656)		
31073	Calandrinia sp. The Pink Hills (F. Obbens FO 19/06)		
2870	Calandrinia stagnensis		
30396	Calandrinia translucens		
8466	Callitris columellaris (White Cypress Pine)		
8637	Callitris verrucosa		
14090	Calocephalus beardii		
7893	Calocephalus knappii		
7895	Calocephalus multiflorus (Yellow-top)		
5398	Calothamnus aridus		
7903	Calotis hispidula (Bindy Eye)		
7905	Calotis multicaulis (Many-stemmed Burr-daisy)		
7906	Calotis plumulifera		
5438	Calytrix amethystina		
5451	Calytrix desolata		
5456	Calytrix erosipetala		
12373	Calytrix uncinata		P3
5486	Calytrix verruculosa		P3
1742	Casuarina obesa (Swamp Sheoak Kuli)		
12658	Casuarina pauper (Black Oak)		
258	Cenchrus ciliaris (Buffel Grass)	Y	
7921	Centipeda thespidioides (Desert Sneezewood)		
7922	Cephalipterum drummondii (Pompom Head)		

42580	Chamelaucium gracile		
32	Cheilanthes brownii		
37	Cheilanthes lasiophylla (Woolly Cloak Fern)		
12818	Cheilanthes sieberi subsp. sieberi		
2489	Chenopodium gaudichaudianum (Cottony Saltbush)		
2494	Chenopodium murale (Nettle-leaf Goosefoot)	Y	
3756	Chorizema genistoides		
33516	Chrysocephalum gilesii		
13138	Chrysocephalum puteale		
7933	Chthonocephalus pseudevax (Woolly Groundheads)		
12619	Chthonocephalus viscosus		
2985	Cleome oxalidea		
2778	Codonocarpus cotinifolius (Native Poplar Kundurangu)		
19881	Convolvulus angustissimus subsp. angustissimus		
6612	Convolvulus clementii		
16780	Corymbia candida subsp. dipsodes		
17077	Corymbia ferriticola		
17095	Corymbia lenziana		
17092	Corymbia opaca		
7943	Cotula australis (Common Cotula)		
7951	Cratystylis subspinescens (Australian Sage		
3010	Cuphonotus andraeanus		
6663	Cuscuta epithymum (Lesser Dodder Greater Dodder)	Y	
11021	Cuscuta planiflora	Y	
279	Cymbopogon ambiguus (Scentgrass)		
281	Cymbopogon obtectus (Silkyheads)		
6584	Cynanchum floribundum (Dumara Bush		
12799	Cyperus betchei subsp. commiscens		
777	Cyperus bulbosus (Bush Onion		
782	Cyperus concinnus		
788	Cyperus dactylotes		
798	Cyperus iria		
814	Cyperus squarrosus		
7433	Dampiera dentata		
7476	Dampiera stenophylla		
6218	Daucus glochidiatus (Australian Carrot)		
3813	Daviesia grahamii		
13741	Dichanthium sericeum subsp. humilius		
7164	Dicladanthera forrestii		
6753	Dicrastylis brunnea		
6759	Dicrastylis flexuosa		
31840	Dicrastylis mitchellii		P1
6774	Dicrastylis sessilifolia		
12721	Dielitzia tysonii		
310	Digitaria brownii (Cotton Panic Grass)		
12023	Diplopeltis stuartii var. stuartii (Desert Pepperflower)		
2499	Dissocarpus paradoxus (Curious Saltbush)		
4757	Dodonaea ceratocarpa		
4761	Dodonaea ericoides		
12034	Dodonaea microzyga var. acrolobata		
4772	Dodonaea pachyneura		
4773	Dodonaea petiolaris		
4779	Dodonaea rigida		
4782	Dodonaea viscosa (Sticky Hopbush)		
11247	Dodonaea viscosa subsp. angustissima		
11202	Dodonaea viscosa subsp. spatulata (Sticky Hop-bush)		
4460	Drummondita miniata		P3
6966	Duboisia hopwoodii (Pituri		
31274	Duperreya commixta		
2500	Dysphania glandulosa		
11632	Dysphania glomulifera subsp. eremaea		
2502	Dysphania kalpari (Rat's Tail		
33597	Dysphania melanocarpa forma melanocarpa (Black Goosefoot)		
2506	Dysphania rhadinostachya		
11653	Dysphania rhadinostachya subsp. inflata		
11890	Dysphania rhadinostachya subsp. rhadinostachya		
33483	Dysphania saxatilis		
828	Eleocharis pallens (Pale Spikerush)		
12064	Enchylaena tomentosa var. tomentosa (Barrier Saltbush)		
19846	Enekbatus eremaeus		
357	Enneapogon caerulescens (Limestone Grass)		
365	Enneapogon polyphyllus (Leafy Nineawn)		
378	Eragrostis dielsii (Mallee Lovegrass)		

380	Eragrostis eriopoda (Woollybutt Grass		
385	Eragrostis lacunaria (Purple Lovegrass)		
387	Eragrostis lanipes (Creeping Wanderrie)		
388	Eragrostis leptocarpa (Drooping Lovegrass)		
392	Eragrostis pergracilis		
393	Eragrostis setifolia (Neverfail Grass)		
398	Eragrostis tenellula (Delicate Lovegrass)		
399	Eragrostis xerophila (Knotty-butt Neverfail)		
2513	Eremophea spinosa		
7180	Eremophila alternifolia (Poverty Bush)		
14508	Eremophila anomala	P1	
7182	Eremophila battii		
7189	Eremophila clarkei (Turpentine Bush)		
17157	Eremophila compacta subsp. compacta		
17155	Eremophila compacta subsp. fecunda		
15177	Eremophila congesta	P1	
12951	Eremophila enata		
7204	Eremophila eriocalyx (Desert Pride)		
7205	Eremophila exilifolia		
7206	Eremophila falcata		
14510	Eremophila fasciata	P3	
16792	Eremophila flabellata		
7207	Eremophila foliosissima		
7208	Eremophila forrestii (Wilcox Bush)		
15052	Eremophila forrestii subsp. forrestii		
17152	Eremophila forrestii subsp. hastieana (Grey Poverty Bush)		
16696	Eremophila fraseri subsp. fraseri		
29532	Eremophila galeata		
7214	Eremophila gilesii (Charleville Turkey Bush)		
16732	Eremophila gilesii subsp. gilesii		
17176	Eremophila gilesii subsp. variabilis		
14340	Eremophila glabra subsp. glabra		
14191	Eremophila glabra subsp. tomentosa		
7216	Eremophila glutinosa		
7219	Eremophila granitica (Thin-leaved Poverty Bush)		
17172	Eremophila hughesii subsp. hughesii		
17189	Eremophila hygrophana		
7226	Eremophila ionantha (Violet-flowered Eremophila)		
17171	Eremophila jucunda subsp. jucunda		
7228	Eremophila lachnocalyx (Woolly-calyxed Eremophila)		
7230	Eremophila latrobei (Warty Fuchsia Bush		
17597	Eremophila latrobei subsp. filiformis		
17169	Eremophila latrobei subsp. glabra		
17576	Eremophila latrobei subsp. latrobei		
7233	Eremophila linearis (Harlequin Fuchsia Bush)		
7234	Eremophila longifolia (Berrigan		
7236	Eremophila macmillaniana (Grey Turpentine Bush)		
16363	Eremophila maculata subsp. brevifolia (Native Fuchsia)		
15157	Eremophila malacoides		
7239	Eremophila margarethae (Sandbank Poverty Bush)		
18211	Eremophila micrantha		
7247	Eremophila oppositifolia (Weeooka)		
18570	Eremophila oppositifolia subsp. angustifolia		
7250	Eremophila pantonii		
15164	Eremophila petrophila subsp. petrophila		
17282	Eremophila phyllopoda		
17167	Eremophila phyllopoda subsp. phyllopoda		
7253	Eremophila platycalyx (Granite Poverty Bush)		
15058	Eremophila platycalyx subsp. platycalyx		
7255	Eremophila pterocarpa (Silver Poverty Bush)		
15170	Eremophila pterocarpa subsp. pterocarpa		
7256	Eremophila punctata		
15027	Eremophila retropila	P1	Y
7269	Eremophila serrulata (Serrate-leaved Eremophila)		
17166	Eremophila simulans subsp. lapidensis		
20236	Eremophila sp. Collier Range (M. Greeve 33)		
7270	Eremophila spathulata (Spoon-leaved Eremophila)		
7271	Eremophila spectabilis (Showy Poverty Bush)		
17163	Eremophila spectabilis subsp. brevis		
17190	Eremophila spectabilis subsp. spectabilis		
15168	Eremophila spuria		
7273	Eremophila strongylophylla		
15155	Eremophila youngii subsp. youngii		

400	Eriachne aristidea	
408	Eriachne flaccida (Claypan Grass)	
411	Eriachne helmsii (Buck Wanderrie Grass)	
413	Eriachne mucronata (Mountain Wanderrie Grass)	
417	Eriachne pulchella (Pretty Wanderrie)	
16485	Eriachne pulchella subsp. dominii	
2514	Eriochiton sclerolaenoides (Woolly Bindii)	
4334	Erodium crinitum (Corkscrew)	
4335	Erodium cygnorum (Blue Heronsbill)	
12718	Erymophyllum compactum	
12739	Erymophyllum ramosum	
14377	Erymophyllum ramosum subsp. ramosum	
35345	Eucalyptus camaldulensis subsp. obtusa (Blunt-budded River Red Gum)	
5583	Eucalyptus carnei (Carne's Blackbutt)	
5636	Eucalyptus eremicola	
20300	Eucalyptus eremicola subsp. peeneri	
5641	Eucalyptus ewartiana (Ewart's Mallee)	
5660	Eucalyptus gongylocarpa (Marble Gum	
18057	Eucalyptus gypsophila	
13528	Eucalyptus kingsmillii subsp. kingsmillii	
13057	Eucalyptus leptopoda subsp. arctata	
13058	Eucalyptus leptopoda subsp. elevata	
5703	Eucalyptus lucasii (Barlee Box)	
13019	Eucalyptus mannensis subsp. mannensis	
5779	Eucalyptus striaticalyx (Cue York Gum)	
29733	Eucalyptus trivalva (Victoria Spring Mallee)	
14548	Eucalyptus victrix	
11011	Eulalia aurea	
4620	Euphorbia boophthona (Gascoyne Spurge)	
4626	Euphorbia drummondii (Caustic Weed	
42869	Euphorbia porcata	
12097	Euphorbia tannensis subsp. eremophila (Desert Spurge)	
17913	Euryomyrtus inflata	P3
10977	Exocarpos aphyllus (Leafless Ballart)	
5191	Frankenia cinerea	
5206	Frankenia laxiflora (Loose Flowered Frankenia)	
5212	Frankenia setosa (Bristly Frankenia)	
7977	Gilruthia osbornei	
3938	Glycine canescens (Silky Glycine)	
7989	Gnephosis brevifolia (Short-leaved Gnephosis)	
8002	Gnephosis tenuissima	
7495	Goodenia berardiana	
12512	Goodenia berringbinensis	P4
7498	Goodenia centralis	
7514	Goodenia havilandii	
12530	Goodenia macroplectra	
7525	Goodenia maideniana	
7527	Goodenia mimuloides	
7529	Goodenia mueckeana	
7533	Goodenia peacockiana	
7543	Goodenia quasilibera	
7556	Goodenia tenuiloba	
7558	Goodenia triodiophila	
7564	Goodenia wilunensis	
1946	Grevillea acacioides	
1963	Grevillea berryana	
1986	Grevillea deflexa	
13453	Grevillea didymobotrya subsp. didymobotrya	
2019	Grevillea inconspicua (Cue Grevillea)	P4
15845	Grevillea juncifolia subsp. juncifolia	
15844	Grevillea juncifolia subsp. temulenta	
19542	Grevillea nematophylla subsp. supraplana	
2077	Grevillea pterosperma	
13459	Grevillea sarissa subsp. succincta	
2099	Grevillea striata (Beefwood)	
2808	Gunniopsis rodwayi	
2163	Hakea francisiana (Emu Tree)	
16921	Hakea leucoptera subsp. sericipes	
19137	Hakea lorea subsp. lorea	
2196	Hakea preissii (Needle Tree	
17556	Hakea recurva subsp. arida	
17557	Hakea recurva subsp. recurva	
2200	Hakea rhombales	

29840	Halgania cyanea var. Allambi Stn (B.W. Strong 676)		
6690	Halgania gustafsenii		
17493	Halgania gustafsenii var. gustafsenii		
6176	Haloragis odontocarpa (Mulga Nettle)		
16371	Haloragis odontocarpa forma pterocarpa		
6180	Haloragis trigonocarpa		
17326	Harnieria kempeana		
17325	Harnieria kempeana subsp. muelleri		
29594	Helichrysum luteoalbum (Jersey Cudweed)		
17299	Heliotropium ammophilum		
6707	Heliotropium curassavicum (Smooth Heliotrope)		
6712	Heliotropium heteranthum		
17307	Heliotropium inexplicitum		
14358	Heliotropium mitchellii		
6713	Heliotropium ovalifolium		
8045	Helipterum craspedioides (Yellow Billy Buttons)		
33779	Hemigenia tomentosa		
33760	Hemigenia virescens		P3
4924	Hibiscus burtonii		
4941	Hibiscus solanifolius		
43022	Hibiscus sp. Gardneri (A.L. Payne PRP 1435)		
4942	Hibiscus sturtii (Sturt's Hibiscus)		
5809	Homalocalyx echinulatus		P3
5814	Homalocalyx staminosus		
5815	Homalocalyx thryptomenoides		
15448	Hyalosperma glutinosum subsp. venustum		
5221	Hybanthus floribundus		
453	Imperata cylindrica (Kunai Grass)		
3970	Indigofera australis (Australian Indigo)		
3974	Indigofera georgei (Bovine Indigo)		
3982	Indigofera monophylla		
41763	Indigofera sp. Chamaeclada (G.J. Keighery & N. Gibson 1224)		
41781	Indigofera sp. Gilesii (M.E. Trudgen 15869)		P3
6621	Ipomoea calobra (Weir Vine)		
459	Iseilema eremaeum		
8087	Isoetopsis graminifolia (Cushion Grass)		
911	Isolepis congrua		
7397	Isotoma petraea (Rock Isotome		
3989	Isotropis atropurpurea (Poison Sage)		
3994	Isotropis forrestii		
7118	Josephinia eugeniae (Josephinia Burr)		
4043	Kennedia prorepens		
19636	Keraudrenia velutina subsp. elliptica		
8094	Kippistia suaedifolia		
17209	Lachnostachys verbascifolia var. verbascifolia		
8096	Lactuca serriola (Prickly Lettuce)	Y	
29046	Lactuca serriola forma serriola	Y	
13289	Lawrencella davenportii		
4953	Lawrencia densiflora		
4956	Lawrencia helmsii (Dunna Dunna)		
12628	Lemooria burkittii		
19989	Lepidium didymum	Y	
3025	Lepidium echinatum		
3033	Lepidium oxytrichum		
3039	Lepidium platypetalum (Slender Peppercress)		
19126	Leptochloa fusca subsp. muelleri		
4055	Leptosema chambersii		
3613	Leucaena leucocephala (Leucaena)	Y	
13258	Leucochrysum stipitatum		
7669	Levenhookia chippendalei		
7671	Levenhookia leptantha (Trumpet Stylewort)		
36881	Lobelia simulans		
6967	Lycium australe (Australian Boxthorn)		
2398	Lysiana murrayi (Mistletoe		
4728	Macgregoria racemigera (Snow Flower)		
2533	Maireana amoena		
2536	Maireana atkinsiana (Bronze Bluebush)		
2537	Maireana brevifolia (Small Leaf Bluebush)		
2538	Maireana carnosa (Cottony Bluebush)		
2539	Maireana convexa (Mulga Bluebush)		
2543	Maireana eriosphaera		
2544	Maireana georgei (Satiny Bluebush)		
2545	Maireana glomerifolia (Ball Leaf Bluebush)		

2551	Maireana melanocoma (Pussy Bluebush)		
2555	Maireana pentatropis		
2556	Maireana planifolia (Low Bluebush)		
2559	Maireana prosthecochaeta		P3
2560	Maireana pyramidata (Sago Bush)		
2566	Maireana thesioides (Lax Bluebush)		
2567	Maireana tomentosa (Felty Bluebush)		
11662	Maireana tomentosa subsp. tomentosa		
2568	Maireana trichoptera (Downy Bluebush)		
2569	Maireana triptera (Threewinged Bluebush)		
2571	Maireana villosa		
4961	Malva parviflora (Marshmallow)	Y	
12949	Marsdenia australis		
16538	Marsdenia graniticola		
74	Marsilea drummondii (Common Nardoo)		
5929	Melaleuca leiocarpa		
19449	Melaleuca stereophloia		
5991	Melaleuca xerophila		
3050	Menkea australis (Fairy Spectacles)		
3051	Menkea draboides		P3
3053	Menkea sphaerocarpa		
3054	Menkea villosula		
5995	Micromyrtus flaviflora		
6003	Micromyrtus sulphurea		
12629	Millotia incurva		
4098	Mirbelia rhagodioides		
4101	Mirbelia stipitata		P3
490	Monachather paradoxus		
4111	Muelleranthus trifoliolatus		
8116	Myriocephalus guerinae		
14186	Myriocephalus pygmaeus		
8121	Myriocephalus rudallii		
6243	Neosciadium glochidiatum		
493	Neurachne lanigera		P1
494	Neurachne minor		
495	Neurachne munroi		
6786	Newcastelia cephalantha		
6791	Newcastelia hexarrhena (Lambs' Tails)		
6972	Nicotiana cavicola (Talara)		
11856	Nicotiana occidentalis subsp. occidentalis		
11734	Nicotiana rosulata subsp. rosulata		
6979	Nicotiana simulans		
12638	Olearia mucronata		P3
8151	Olearia stuartii		
8153	Olearia xerophila		
17	Ophioglossum lusitanicum (Adders Tongue)		
4355	Oxalis perennans		
2964	Papaver hybridum (Rough Poppy)	Y	
514	Paractaenum refractum		
12670	Parietaria cardiostegia		
10975	Paspalidium basicladum		
518	Paspalidium clementii (Clements Paspalidium)		
519	Paspalidium constrictum (Knottybutt Grass)		
12486	Peplidium aithocheilum		
18463	Peplidium sp. C Evol. Fl. Fauna Arid Aust. (N.T. Burbidge & A. Kanis 8158)		
546	Perotis rara (Comet Grass)		
3674	Petalostylis cassioides		
17626	Phyllanthus erwinii		
13229	Phyllota humilis		
5245	Pimelea forrestiana		
5250	Pimelea holroydii		
5256	Pimelea microcephala (Shrubby Riceflower		
11185	Pimelea microcephala subsp. microcephala		
5271	Pimelea trichostachya (Spiked Riceflower)		
19744	Pittosporum angustifolium		
10974	Plagiobothrys plurisepalus		
8172	Podolepis canescens (Bright Podolepis		
8173	Podolepis capillaris (Wiry Podolepis)		
8174	Podolepis gardneri		
8176	Podolepis kendallii		
41365	Polygala glaucifolia		
4572	Polygala isingii		
2879	Portulaca cyclophylla		

2884	Portulaca oleracea (Purslane Wakati)	Y	
12707	Prostanthera albiflora		
15822	Prostanthera althoferi subsp. althoferi		
6912	Prostanthera campbellii		
31783	Prostanthera ferricola		P3
6926	Prostanthera wilkieana		
18206	Psydrax attenuata		
18154	Psydrax latifolia		
18210	Psydrax rigidula		
18155	Psydrax suaveolens		
2690	Ptilotus aervoides		
2691	Ptilotus albidus		
2708	Ptilotus chamaecladus		
2709	Ptilotus chippendalei		
23487	Ptilotus chrysocomus		P1
2717	Ptilotus divaricatus (Climbing Mulla Mulla)		
2718	Ptilotus drummondii (Narrowleaf Mulla Mulla)		
11797	Ptilotus drummondii var. minor		
2727	Ptilotus gaudichaudii		
41506	Ptilotus gaudichaudii subsp. gaudichaudii		
2729	Ptilotus grandiflorus		
2731	Ptilotus helipteroides (Hairy Mulla Mulla)		
2739	Ptilotus lazaridis		P3
35576	Ptilotus luteolus		P3
2741	Ptilotus macrocephalus (Featherheads)		
2746	Ptilotus nobilis (Tall Mulla Mulla)		
41001	Ptilotus nobilis subsp. nobilis (Yellow Tails)		
2747	Ptilotus obovatus (Cotton Bush)		
11396	Ptilotus obovatus var. obovatus		
2751	Ptilotus polystachyus (Prince of Wales Feather)		
2754	Ptilotus roei		
2755	Ptilotus rotundifolius (Royal Mulla Mulla)		
2757	Ptilotus schwartzii		
11219	Ptilotus schwartzii var. georgei		
15855	Ptilotus schwartzii var. schwartzii		
2581	Rhagodia drummondii		
2582	Rhagodia eremaea (Thorny Saltbush)		
13306	Rhodanthe battii		
13308	Rhodanthe charsleyae		
13241	Rhodanthe chlorocephala subsp. rosea		
13242	Rhodanthe chlorocephala subsp. splendida		
13301	Rhodanthe floribunda		
13246	Rhodanthe humboldtiana		
13238	Rhodanthe maryonii		
13251	Rhodanthe propinqua		
13303	Rhodanthe sterilescens		
13254	Rhodanthe stricta		
6599	Rhyncharrhena linearis (Bush Bean		
11151	Rostraria pumila	Y	
30434	Salsola australis		
6484	Samolus repens (Creeping Brookweed)		
2357	Santalum lanceolatum (Northern Sandalwood		
2359	Santalum spicatum (Sandalwood		
13006	Sarcostemma viminale subsp. australe		
13178	Scaevola amblyanthera var. centralis		
7604	Scaevola collaris		
7644	Scaevola spinescens (Currant Bush		
7648	Scaevola tomentosa (Raggedleaf Fanflower)		
13285	Schoenia ayersii		
8200	Schoenia cassiniana (Schoenia)		
13287	Schoenia filifolia subsp. filifolia		
2600	Sclerolaena burbidgeae		
2603	Sclerolaena cornishiana (Cartwheel Burr)		
2606	Sclerolaena cuneata (Yellow Bindii)		
2607	Sclerolaena densiflora		
2611	Sclerolaena eriacantha (Tall Bindii)		
2612	Sclerolaena eurotioides (Fluffy Bindii)		
2613	Sclerolaena fimbriolata		
2615	Sclerolaena fusiformis		
8877	Sclerolaena gardneri		
2619	Sclerolaena lanicuspis (Spinach Burr)		
2622	Sclerolaena microcarpa		
2625	Sclerolaena obliquicuspis (Limestone Bindii)		

2628	Sclerolaena recurvicuspis		
8207	Senecio glossanthus (Slender Groundsel)		
9366	Senecio gregorii (Fleshy Groundsel)		
25881	Senecio lacustrinus		
17645	Senna artemisioides		
12276	Senna artemisioides subsp. filifolia		
12279	Senna artemisioides subsp. helmsii		
17558	Senna artemisioides subsp. x artemisioides		
12283	Senna artemisioides subsp. x sturtii		
18444	Senna charlesiana		
18449	Senna glaucifolia		
18346	Senna glutinosa		
12305	Senna glutinosa subsp. chatelainiana		
12309	Senna glutinosa subsp. pruinosa		
12308	Senna glutinosa subsp. x luerssenii		
16378	Senna pleurocarpa		
12314	Senna pleurocarpa var. pleurocarpa		
14579	Senna sp. Austin (A. Strid 20210)		
14577	Senna sp. Meekatharra (E. Bailey 1-26)		
18445	Senna stricta		
613	Setaria verticillata (Whorled Pigeon Grass)	Y	
4970	Sida calyxhymenia (Tall Sida)		
31759	Sida ectogama		
40861	Sida picklesiana		P3
19712	Sida sp. dark green fruits (S. van Leeuwen 2260)		
31854	Sida sp. Excedentifolia (J.L. Egan 1925)		
31857	Sida sp. Golden calyces glabrous (H.N. Foote 32)		
16948	Sida sp. verrucose glands (F.H. Mollemans 2423)		
16924	Sida spodochroma		
3069	Sisymbrium erysimoides (Smooth Mustard)	Y	
3072	Sisymbrium orientale (Indian Hedge Mustard)	Y	
42547	Solanum austropiceum		
6995	Solanum centrale (Desert Raisin		
6998	Solanum cleistogamum		
6999	Solanum coactiliferum (Western Nightshade)		
7016	Solanum lachnophyllum		
7018	Solanum lasiophyllum (Flannel Bush		
7022	Solanum nigrum (Black Berry Nightshade)	Y	
7023	Solanum nummularium (Money-leaved Solanum)		
7025	Solanum oldfieldii		
7026	Solanum orbiculatum (Wild Tomato)		
11241	Solanum orbiculatum subsp. orbiculatum (Round-leaved Solanum)		
7038	Solanum terraneum		
6827	Spartothamnella teucriiflora		
8900	Spergularia marina	Y	
628	Sporobolus actinocladus (Ray Grass		
629	Sporobolus australasicus (Fairy Grass)		
4729	Stackhousia clementii		P3
16199	Stenanthemum petraeum		
3074	Stenopetalum anfractum		
3076	Stenopetalum filifolium		
3078	Stenopetalum nutans		
8234	Streptoglossa adscendens		
8236	Streptoglossa cylindriceps		
8238	Streptoglossa liatroides		
7740	Stylidium induratum (Desert Triggerplant)		
7754	Stylidium longibracteatum (Long-bracted Trigger Plant)		
12355	Swainsona affinis		
4220	Swainsona canescens (Grey Swainsona)		
13595	Swainsona elegantoides		
12356	Swainsona formosa		
4231	Swainsona kingii		
4233	Swainsona leeana		
4238	Swainsona oroboides (Variable Swainsona)		
13581	Swainsona paradoxa		
13586	Swainsona paucifoliolata		
4239	Swainsona pedunculata		
4242	Swainsona pterostylis		
12357	Swainsona purpurea		
13585	Swainsona tenuis		
13339	Synaptantha tillaeacea var. tillaeacea		
12729	Taplinia saxatilis		
31844	Tecticornia cymbiformis		P3

31492	Tecticornia disarticulata		
33236	Tecticornia halocnemoides (Shrubby Samphire)		
33239	Tecticornia halocnemoides subsp. catenulata		
33319	Tecticornia indica subsp. bidens		
33220	Tecticornia pterygosperma subsp. denticulata		
31851	Tecticornia sp. Yoothapina Station (A.A. Mitchell 883)		
2819	Tetragonia cristata		
16287	Tetragonia moorei		
40680	Tetragonia tetragonioides (New Zealand Spinach)		
6936	Teucrium racemosum (Grey Germander)		
673	Themeda triandra		
6054	Thryptomene decussata		
674	Thyridolepis mitchelliana (Mulga Grass)		
675	Thyridolepis multiculmis (Soft Wanderrie Grass)		
1338	Thysanotus manglesianus (Fringed Lily)		
29457	Thysanotus sp. Eremaean (S. van Leeuwen 1067)		
1352	Thysanotus speckii		
12649	Tietkensia corrickiae		
6265	Trachymene bialata		
6279	Trachymene ornata (Spongefruit)		
2826	Trianthema glossostigma		
2832	Trianthema triquetra (Red Spinach)		
18065	Tribulus adelacanthus	P3	
4374	Tribulus astrocarpus		
4377	Tribulus hirsutus		
4381	Tribulus platypterus (Cork Hopbush)		
18072	Tribulus suberosus		
6727	Trichodesma zeylanicum (Camel Bush		
33276	Triglochin isingiana		
680	Triodia basedowii (Lobed Spinifex)		
682	Triodia concinna		
17877	Triodia melvillei		
699	Triodia scariosa		
705	Tripogon loliiformis (Five Minute Grass)		
717	Urochloa piligera		
7658	Velleia discophora (Cabbage Poison)		
7660	Velleia glabrata (Pee the Bed)		
7661	Velleia hispida (Hispid Velleia)		
12436	Verticordia interioris		
8273	Vittadinia sulcata		
7393	Wahlenbergia tumidifructa		
8275	Waitzia acuminata (Orange Immortelle)		
13331	Waitzia acuminata var. acuminata		
1392	Wurmbea deserticola		
31335	Wurmbea sp. Denham Pool (F. Hort et al. 2216)	P1	Y
4386	Zygophyllum aurantiacum (Shrubby Twinleaf)		
4388	Zygophyllum compressum		
18140	Zygophyllum eichleri		
4392	Zygophyllum iodocarpum		
4393	Zygophyllum kochii		
4394	Zygophyllum ovatum (Dwarf Twinleaf)		
17278	Zygophyllum tetrapterum		

Naturemap Search combined 50 km buffer 17/10/13

Name ID	Species Name	Naturalised	Conservation Code
24559	Acanthagenys rufogularis (Spiny-cheeked Honeyeater)		
24260	Acanthiza apicalis (Broad-tailed Thornbill Inland Thornbill)		
24261	Acanthiza chrysorrhoa (Yellow-rumped Thornbill)		
24264	Acanthiza robustirostris (Slaty-backed Thornbill)		
24265	Acanthiza uropygialis (Chestnut-rumped Thornbill)		
24281	Accipiter cirrocephalus subsp. cirrocephalus (Collared Sparrowhawk)		
25536	Accipiter fasciatus (Brown Goshawk)		
25544	Aegotheles cristatus (Australian Owlet-nightjar)		
30833	Amphibolurus longirostris		
24539	Amytornis striatus subsp. striatus (Striated Grasswren (inland))		P4
24312	Anas gracilis (Grey Teal)		
24315	Anas rhynchotis (Australasian Shoveler)		
24316	Anas superciliosa (Pacific Black Duck)		
25318	Antaresia perthensis (Pygmy Python)		
25241	Antaresia stimsoni subsp. stimsoni (Stimson's Python)		
24087	Antechinomys laniger (Kultarr)		
25528	Aphelocephala leucopsis (Southern Whiteface)		
24266	Aphelocephala leucopsis subsp. castaneiventris (Southern Whiteface)		
24268	Aphelocephala nigricincta (Banded Whiteface)		
24285	Aquila audax (Wedge-tailed Eagle)		
24340	Ardea novaehollandiae (White-faced Heron)		
24341	Ardea pacifica (White-necked Heron)		
24610	Ardeotis australis (Australian Bustard)		P4
-1751	Argiope protensa		
-12015	Arrenurus separatus		
25566	Artamus cinereus (Black-faced Woodswallow)		
24356	Artamus personatus (Masked Woodswallow)		
24318	Aythya australis (Hardhead)		
24161	Bettongia lesueur subsp. graii (Boodie Burrowing Bettong)		
24319	Biziura lobata (Musk Duck)		
24251	Bos taurus (European Cattle)	Y	
25331	Brachyurophis approximans		
25715	Cacatua roseicapilla (Galah)		
24725	Cacatua roseicapilla subsp. assimilis (Galah)		
25716	Cacatua sanguinea (Little Corella)		
24727	Cacatua sanguinea subsp. westralensis (Little Corella)		
42307	Cacomantis pallidus (Pallid Cuckoo)		
30883	Canis lupus subsp. familiaris (Dog)	Y	
24564	Certhionyx variegatus (Pied Honeyeater)		
24186	Chalinolobus gouldii (Gould's Wattled Bat)		
24377	Charadrius ruficapillus (Red-capped Plover)		
25339	Chelodina steindachneri (Flat-shelled Turtle)		
24488	Cheramoeca leucosternus (White-backed Swallow)		
24434	Chrysococcyx osculans (Black-eared Cuckoo)		
24833	Cincloramphus cruralis (Brown Songlark)		
24834	Cincloramphus mathewsi (Rufous Songlark)		
25580	Cinclosoma castaneothorax (Chestnut-breasted Quail-thrush)		
42311	Cinclosoma marginatum (Western Quail-thrush)		
24289	Circus assimilis (Spotted Harrier)		
24774	Cladorhynchus leucocephalus (Banded Stilt)		
25675	Colluricincla harmonica (Grey Shrike-thrush)		
24399	Columba livia (Domestic Pigeon)	Y	
24361	Coracina maxima (Ground Cuckoo-shrike)		
25568	Coracina novaehollandiae (Black-faced Cuckoo-shrike)		
24362	Coracina novaehollandiae subsp. novaehollandiae (Black-faced Cuckoo-shrike)		
24416	Corvus bennetti (Little Crow)		
25593	Corvus orru (Torresian Crow)		
24420	Cracticus nigrogularis (Pied Butcherbird)		
25595	Cracticus tibicen (Australian Magpie)		
25596	Cracticus torquatus (Grey Butcherbird)		
25458	Ctenophorus caudicinctus (Ring-tailed Dragon)		
24865	Ctenophorus caudicinctus subsp. caudicinctus (Ring-tailed Dragon)		
24869	Ctenophorus caudicinctus subsp. mensarum (Ring-tailed Dragon)		
25459	Ctenophorus isolepis (Crested Dragon Military Dragon)		
24875	Ctenophorus isolepis subsp. gularis (Central Military Dragon)		

24882	Ctenophorus nuchalis (Central Netted Dragon)	
24886	Ctenophorus reticulatus (Western Netted Dragon)	
24888	Ctenophorus salinarum (Salt Pan Dragon)	
24889	Ctenophorus scutulatus	
25045	Ctenotus helenae	
25052	Ctenotus leonhardii	
25054	Ctenotus mimetes	
25463	Ctenotus pantherinus (Leopard Ctenotus)	
25375	Cyclorana maini (Sheep Frog)	
25376	Cyclorana platycephala (Water-holding Frog)	
24322	Cygnus atratus (Black Swan)	
-11830	Cyrtophora parnasia	
24089	Dasycercus cristicauda (Crest-tailed Mulgara)	T
24997	Delma butleri	
25295	Demansia psammophis subsp. cupreiceps (Yellow-faced Whipsnake)	
25607	Dicaeum hirundinaceum (Mistletoebird)	
25469	Diplodactylus granariensis	
24940	Diplodactylus pulcher	
24470	Dromaius novaehollandiae (Emu)	
25092	Egernia depressa (Southern Pygmy Spiny-tailed Skink)	
24568	Epthianura aurifrons (Orange Chat)	
24570	Epthianura tricolor (Crimson Chat)	
25109	Eremiascincus richardsonii (Broad-banded Sand Swimmer)	
24379	Erythrogonys cinctus (Red-kneed Dotterel)	
-1632	Ethmostigmus rubripes	
24368	Eurostopodus argus (Spotted Nightjar)	
25621	Falco berigora (Brown Falcon)	
25622	Falco cenchroides (Australian Kestrel)	
25623	Falco longipennis (Australian Hobby)	
25624	Falco peregrinus (Peregrine Falcon)	S
24476	Falco subniger (Black Falcon)	
25727	Fulica atra (Eurasian Coot)	
-11605	Gaius villosus	
24764	Gallinula ventralis (Black-tailed Native-hen)	
24958	Gehyra punctata	
24959	Gehyra variegata	
24401	Geopelia cuneata (Diamond Dove)	
25530	Gerygone fusca (Western Gerygone)	
-13630	Gerygone fusca subsp. mungi	
-13764	Gerygone mungi	
24443	Grallina cyanoleuca (Magpie-lark)	
24295	Haliastur sphenurus (Whistling Kite)	
24297	Hamirostra melanosternon (Black-breasted Buzzard)	
24961	Heteronotia binoei (Bynoe's Gecko)	
25734	Himantopus himantopus (Black-winged Stilt)	
24775	Himantopus himantopus subsp. leucocephalus (Black-winged Stilt)	
24491	Hirundo neoxena (Welcome Swallow)	
-12116	Hoggicosa bicolor	
-12203	Hoggicosa forresti	
24367	Lalage tricolor (White-winged Triller)	
-1712	Lampona cylindrata	
24511	Larus novaehollandiae subsp. novaehollandiae (Silver Gull)	
24557	Leipoa ocellata (Malleefowl)	T
25125	Lerista bipes	
25134	Lerista eupoda (Good-legged Lerista skink)	
25151	Lerista macropisthopus subsp. fusciceps	
25155	Lerista muelleri	
42411	Lerista timida	
25661	Lichmera indistincta (Brown Honeyeater)	
25392	Litoria rubella (Little Red Tree Frog)	
42415	Lucasium squarrosum	
30933	Lucasium stenodactylum	
30934	Lucasium wombeyi	
25489	Macropus robustus (Euro)	
24135	Macropus robustus subsp. erubescens (Euro Biggada)	
24136	Macropus rufus (Red Kangaroo Marlu)	
24168	Macrotis lagotis (Bilby Dalgyte)	

24326	Malacorhynchus membranaceus (Pink-eared Duck)	
25651	Malurus lamberti (Variegated Fairy-wren)	
25652	Malurus leucopterus (White-winged Fairy-wren)	
25654	Malurus splendens (Splendid Fairy-wren)	
24583	Manorina flavigula (Yellow-throated Miner)	
24736	Melopsittacus undulatus (Budgerigar)	
25184	Menetia greyii	
24598	Merops ornatus (Rainbow Bee-eater)	IA
25542	Milvus migrans (Black Kite)	
25190	Morethia butleri	
24182	Mormopterus beccarii (Beccari's Freetail-bat)	
24737	Neophema bourkii (Bourke's Parrot)	
24971	Nephrurus vertebralis	
24973	Nephrurus wheeleri subsp. wheeleri	
24094	Ningaui ridei (Wongai Ningaui)	
25748	Ninox novaeseelandiae (Boobook Owl)	
-12091	Nomindra leeuweni	
24224	Notomys alexis (Spinifex Hopping-mouse)	
-12329	Notsodipus meedo	
24194	Nyctophilus geoffroyi (Lesser Long-eared Bat)	
24742	Nymphicus hollandicus (Cockatiel)	
24407	Ocyphaps lophotes (Crested Pigeon)	
24618	Oreoica gutturalis (Crested Bellbird)	
25680	Pachycephala rufiventris (Rufous Whistler)	
25254	Parasuta monachus	
24627	Pardalotus rubricatus (Red-browed Pardalote)	
25682	Pardalotus striatus (Striated Pardalote)	
24628	Pardalotus striatus subsp. murchisoni (Striated Pardalote)	
-1785	Pediana tenuis	
24648	Pelecanus conspicillatus (Australian Pelican)	
24659	Petroica goodenovii (Red-capped Robin)	
24409	Phaps chalcoptera (Common Bronzewing)	
24841	Platalea flavipes (Yellow-billed Spoonbill)	
25721	Platycercus zonarius (Australian Ringneck Ring-necked Parrot)	
24751	Platycercus zonarius subsp. zonarius (Port Lincoln Parrot)	
25703	Podargus strigoides (Tawny Frogmouth)	
24679	Podargus strigoides subsp. brachypterus (Tawny Frogmouth)	
25510	Pogona minor (Dwarf Bearded Dragon)	
24681	Poliocephalus poliocephalus (Hoary-headed Grebe)	
24683	Pomatostomus superciliosus (White-browed Babbler)	
25706	Pomatostomus temporalis (Grey-crowned Babbler)	
24684	Pomatostomus temporalis subsp. rubeculus (Grey-crowned Babbler)	
24106	Pseudantechinus woolleyae (Woolley's Pseudantechinus)	
42416	Pseudonaja mengdeni (Western Brown Snake)	
25263	Pseudonaja modesta (Ringed Brown Snake)	
24390	Psophodes occidentalis (Western Wedgebill Chiming Wedgebill)	
25724	Ptilonorhynchus maculatus (Spotted Bowerbird)	
24757	Ptilonorhynchus maculatus subsp. guttatus (Western Bowerbird)	
42344	Purnella albifrons (White-fronted Honeyeater)	
25009	Pygopus nigriceps	
24278	Pyrrholaemus brunneus (Redthroat)	
25277	Ramphotyphlops grypus	
25279	Ramphotyphlops hamatus	
25288	Ramphotyphlops waitii	
25614	Rhipidura leucophrys (Willie Wagtail)	
24982	Rhynchoedura ornata (Western Beaked Gecko)	
-1812	Scolopendra morsitans	
24199	Scotorepens balstoni (Inland Broad-nosed Bat)	
25266	Simoselaps bertholdi (Jan's Banded Snake)	
30948	Smicrornis brevirostris (Weebill)	
24108	Sminthopsis crassicaudata (Fat-tailed Dunnart)	
24109	Sminthopsis dolichura (Little long-tailed Dunnart)	
24115	Sminthopsis longicaudata (Long-tailed Dunnart)	P4
24116	Sminthopsis macroura (Stripe-faced Dunnart)	
24532	Sterna nilotica subsp. macrotarsa (Australian Gull-billed Tern)	
24329	Stictonetta naevosa (Freckled Duck)	
25597	Strepera versicolor (Grey Currawong)	

24927	Strophurus elderi		
24949	Strophurus wellingtonae		
42310	Sugomel niger (Black Honeyeater)		
25269	Suta fasciata (Rosen's Snake)		
25705	Tachybaptus novaehollandiae (Australasian Grebe Black-throated Grebe)		
24185	Tadarida australis (White-striped Freetail-bat)		
24331	Tadorna tadornoides (Australian Shelduck Mountain Duck)		
30870	Taeniopygia guttata (Zebra Finch)		
30871	Taeniopygia guttata subsp. castanotis (Zebra Finch)		
-13360	Thereuopoda lesueurii		
24845	Threskiornis spinicollis (Straw-necked Ibis)		
42351	Todiramphus pyrrhopygius (Red-backed Kingfisher)		
25549	Todiramphus sanctus (Sacred Kingfisher)		
-13062	Trichocyclus nigropunctatus		
24851	Turnix velox (Little Button-quail)		
30814	Tympanocryptis cephalus (Pebble Dragon)		
24855	Tyto novaehollandiae subsp. novaehollandiae (Masked Owl (southern subsp))		P3
-1670	Urodacus armatus		
-1642	Urodacus hoplurus		
25211	Varanus caudolineatus		
25218	Varanus gouldii (Bungarra or Sand Monitor)		
25524	Varanus panoptes (Yellow-spotted Monitor)		
25223	Varanus panoptes subsp. rubidus		
24205	Vespadelus finlaysoni (Finlayson's Cave Bat)		
24040	Vulpes vulpes (Red Fox)	Y	

Appendix D – Flora data

Flora species list for the Survey Area

Flora likelihood of occurrence assessment

Table D.1 Flora list recorded in the Survey Area during the field survey

Family	Taxon	Status
Acanthaceae	*Harnieria kempeana* subsp. *muelleri*	
Aizoaceae	*Gunniopsis propinqua*	Priority 3
Aizoaceae	*Tetragonia cristata*	
Aizoaceae	*Trianthema glossostigma*	
Amaranthaceae	*Alternanthera angustifolia*	
Amaranthaceae	*Alternanthera nodiflora*	
Amaranthaceae	*Ptilotus aervoides*	
Amaranthaceae	*Ptilotus artholasius*	
Amaranthaceae	*Ptilotus divaricatus*	
Amaranthaceae	*Ptilotus gaudichaudii* subsp. *gaudichaudii*	
Amaranthaceae	*Ptilotus helipteroides*	
Amaranthaceae	*Ptilotus luteolus*	Priority 3
Amaranthaceae	*Ptilotus macrocephalus*	
Amaranthaceae	*Ptilotus nobilis*	
Amaranthaceae	*Ptilotus obovatus*	
Amaranthaceae	*Ptilotus polystachyus*	
Amaranthaceae	*Ptilotus roei*	
Amaranthaceae	*Ptilotus rotundifolius*	
Amaranthaceae	*Ptilotus schwartzii*	
Amaranthaceae	*Ptilotus schwartzii* var. *georgei*	
Apocynaceae	*Marsdenia australis*	
Apocynaceae	*Rhyncharrhena linearis*	
Apocynaceae	*Sarcostemma viminale* subsp. *australe*	
Araliaceae	*Trachymene* sp. (insufficient material)	
Asparagaceae	*Lomandra leucocephala* subsp. *robusta*	
Asparagaceae	*Thysanotus* sp. (insufficient material)	
Asteraceae	*Actinobole uliginosum*	
Asteraceae	*Actinobole oldfieldianum*	
Asteraceae	*Angianthus milnei*	
Asteraceae	*Bidens bipinnata*	*
Asteraceae	*Brachyscome ciliaris*	
Asteraceae	*Brachyscome ciliaris* var. *lanuginosa*	
Asteraceae	*Brachyscome oncocarpa*	
Asteraceae	*Calocephalus beardii*	
Asteraceae	*Calocephalus multiflorus*	
Asteraceae	*Calotis hispidula*	
Asteraceae	*Calotis* sp. (insufficient material)	
Asteraceae	*Centipeda thespidioides*	
Asteraceae	*Centipeda* sp. (insufficient material)	
Asteraceae	*Cephalipterum drummondii*	
Asteraceae	*Chrysocephalum puteale*	
Asteraceae	*Chthonocephalus pseudevax*	
Asteraceae	*Chthonocephalus viscosus*	

Family	Taxon	Status
Asteraceae	*Dielitzia tysonii*	
Asteraceae	*Erymophyllum ramosum* subsp. *ramosum*	
Asteraceae	*Gnephosis arachnoidea*	
Asteraceae	*Gnephosis brevifolia*	
Asteraceae	*Gnephosis eriocephala*	
Asteraceae	*Gnephosis tenuissima*	
Asteraceae	*Helipterum craspedioides*	
Asteraceae	*Lemooria burkittii*	
Asteraceae	*Myriocephalus oldfieldii*	
Asteraceae	*Myriocephalus rudallii*	
Asteraceae	*Olearia stuartii*	
Asteraceae	*Pluchea dentex*	
Asteraceae	*Podolepis capillaris*	
Asteraceae	*Pterocaulon sphacelatum*	Range Extension
Asteraceae	*Rhodanthe chlorocephala*	
Asteraceae	*Rhodanthe floribunda*	
Asteraceae	*Rhodanthe* sp. (insufficient material)	
Asteraceae	*Rhodanthe sterilescens*	
Asteraceae	*Senecio* sp. (insufficient material)	
Asteraceae	*Streptoglossa cylindriceps*	
Asteraceae	*Streptoglossa liatroides*	
Asteraceae	*Tietkensia corrickiae*	
Asteraceae	*Vittadinia sulcata*	
Asteraceae	*Waitzia acuminata* var. *acuminata*	
Boraginaceae	*Trichodesma zeylanicum*	
Brassicaceae	*Lepidium echinatum*	
Brassicaceae	*Lepidium oxytrichum*	
Brassicaceae	*Menkea villosula*	
Brassicaceae	*Stenopetalum ?filifolium* (insufficient material)	
Brassicaceae	*Stenopetalum anfractum*	
Campanulaceae	*Lobelia heterophylla*	
Campanulaceae	*Lobelia* sp. (insufficient material)	
Campanulaceae	*Wahlenbergia gracilenta*	
Campanulaceae	*Wahlenbergia* sp. (insufficient material)	
Campanulaceae	*Wahlenbergia tumidifructa*	
Casuarinaceae	*Casuarina obesa*	
Casuarinaceae	*Casuarina pauper*	
Celastraceae	*Stackhousia clementii*	Priority 3
Celastraceae	*Stackhousia* sp. Mt Keith (G. Cockerton & G. O'Keefe 11017)	
Chenopodiaceae	*Atriplex codonocarpa*	
Chenopodiaceae	*Atriplex nummularia*	
Chenopodiaceae	*Atriplex semilunaris*	
Chenopodiaceae	*Chenopodium gaudichaudianum*	
Chenopodiaceae	*Dissocarpus paradoxus*	

Family	Taxon	Status
Chenopodiaceae	*Dysphania glomulifera* subsp. *eremaea*	
Chenopodiaceae	*Dysphania kalpari*	
Chenopodiaceae	*Dysphania melanocarpa*	
Chenopodiaceae	*Einadia nutans*	
Chenopodiaceae	*Enchylaena tomentosa*	
Chenopodiaceae	*Maireana carnosa*	
Chenopodiaceae	*Maireana georgei*	
Chenopodiaceae	*Maireana glomerifolia*	
Chenopodiaceae	*Maireana lobiflora*	
Chenopodiaceae	*Maireana melanocoma*	
Chenopodiaceae	*Maireana planifolia*	
Chenopodiaceae	*Maireana* sp. (insufficient material)	
Chenopodiaceae	*Maireana thesioides*	
Chenopodiaceae	*Maireana tomentosa* subsp. *tomentosa*	
Chenopodiaceae	*Maireana trichoptera*	
Chenopodiaceae	*Maireana triptera*	
Chenopodiaceae	*Maireana villosa*	
Chenopodiaceae	*Rhagodia eremaea*	
Chenopodiaceae	*Salsola australis*	
Chenopodiaceae	*Sclerolaena cornishiana*	
Chenopodiaceae	*Sclerolaena cuneata*	
Chenopodiaceae	*Sclerolaena densiflora*	
Chenopodiaceae	*Sclerolaena diacantha*	
Chenopodiaceae	*Sclerolaena eriacantha*	
Chenopodiaceae	*Sclerolaena eurotioides*	
Chenopodiaceae	*Sclerolaena fusiformis*	
Chenopodiaceae	*Sclerolaena lanicuspis*	
Chenopodiaceae	*Sclerolaena obliquicuspis*	
Chenopodiaceae	*Tecticornia calyptrata*	
Chenopodiaceae	*Tecticornia* sp. (insufficient material)	
Convolvulaceae	*Cuscuta planiflora*	*
Convolvulaceae	*Duperreya commixta*	
Convolvulaceae	*Duperreya sericea*	
Crassulaceae	*Crassula colorata*	
Cucurbitaceae	*Citrullus lanatus*	*
Cupressaceae	*Callitris columellaris*	
Cupressaceae	*Callitris* sp. (insufficient material)	
Cyperaceae	*Cyperus betchei* subsp. *commiscens*	
Cyperaceae	*Cyperus iria*	
Cyperaceae	*Isolepis congrua*	
Euphorbiaceae	*Euphorbia boophthona*	
Euphorbiaceae	*Euphorbia drummondii*	
Euphorbiaceae	*Euphorbia* sp. (insufficient material)	
Fabaceae	*?Daviesia* sp.(insufficient material)	

Family	Taxon	Status
Fabaceae	*Acacia ?balsamea*	
Fabaceae	*Acacia ?caesaneura x incurvaneura*	
Fabaceae	*Acacia ?grasbyi*	
Fabaceae	*Acacia ?mulganeura x incurvaneura*	
Fabaceae	*Acacia aneura*	
Fabaceae	*Acacia aptaneura*	
Fabaceae	*Acacia ayersiana*	
Fabaceae	*Acacia ayersiana* (narrow phyllode variant)	
Fabaceae	*Acacia burkittii*	
Fabaceae	*Acacia caesaneura*	
Fabaceae	*Acacia caesaneura* (narrow phyllode variant)	
Fabaceae	*Acacia caesaneura* (short phyllode variant)	
Fabaceae	*Acacia craspedocarpa*	
Fabaceae	*Acacia craspedocarpa* (hybrid)	
Fabaceae	*Acacia effusifolia*	
Fabaceae	*Acacia exocarpoides*	
Fabaceae	*Acacia fuscaneura*	
Fabaceae	*Acacia incurvaneura*	
Fabaceae	*Acacia jamesiana*	
Fabaceae	*Acacia kempeana*	
Fabaceae	*Acacia ligulata*	
Fabaceae	*Acacia macraneura*	
Fabaceae	*Acacia minyura*	
Fabaceae	*Acacia mulganeura*	
Fabaceae	*Acacia murrayana*	
Fabaceae	*Acacia oswaldii*	
Fabaceae	*Acacia pachyacra*	
Fabaceae	*Acacia pruinocarpa*	
Fabaceae	*Acacia pteraneura*	
Fabaceae	*Acacia quadrimarginea*	
Fabaceae	*Acacia ramulosa* var. *linophylla*	
Fabaceae	*Acacia ramulosa* var. *ramulosa*	
Fabaceae	*Acacia rhodophloia*	
Fabaceae	*Acacia sclerosperma* subsp. *sclerosperma*	
Fabaceae	*Acacia sibirica*	
Fabaceae	*Acacia synchronicia*	
Fabaceae	*Acacia tetragonophylla*	
Fabaceae	*Acacia tysonii*	
Fabaceae	*Acacia victoriae*	
Fabaceae	*Acacia wanyu*	
Fabaceae	*Gastrolobium laytonii*	
Fabaceae	*Glycine ?canescens*	
Fabaceae	*Indigofera australis*	
Fabaceae	*Indigofera georgei*	

Family	Taxon	Status
Fabaceae	*Indigofera monophylla*	
Fabaceae	*Indigofera* sp. Gilesii (M.E. Trudgen 15869)	Priority 3
Fabaceae	*Leptosema chambersii*	
Fabaceae	*Mirbelia rhagodioides*	
Fabaceae	*Senna ?stricta*	
Fabaceae	*Senna artemisioides* subsp. *filifolia*	
Fabaceae	*Senna artemisioides* subsp. *helmsii*	
Fabaceae	*Senna artemisioides* subsp. *petiolaris*	
Fabaceae	*Senna artemisioides* subsp. x *artemisioides*	
Fabaceae	*Senna artemisioides* subsp. x *sturtii*	
Fabaceae	*Senna charlesiana*	
Fabaceae	*Senna glutinosa* subsp. *glutinosa*	
Fabaceae	*Senna glutinosa* subsp. x *luerssenii*	
Fabaceae	*Senna pleurocarpa*	
Fabaceae	*Senna pleurocarpa* var. *angustifolia*	
Fabaceae	*Senna* sp. Meekatharra (E. Bailey 1-26)	
Fabaceae	*Swainsona canescens*	
Fabaceae	*Swainsona purpurea*	
Frankeniaceae	*Frankenia setosa*	
Frankeniaceae	*Frankenia* sp. (insufficient material)	
Gentianaceae	*Schenkia australis*	
Geraniaceae	*Erodium cygnorum*	
Geraniaceae	*Erodium* sp. (insufficient material)	
Goodeniaceae	*Brunonia australis*	
Goodeniaceae	*Goodenia ?triodiophila*	
Goodeniaceae	*Goodenia centralis*	
Goodeniaceae	*Goodenia havilandii*	
Goodeniaceae	*Goodenia mimuloides*	
Goodeniaceae	*Goodenia quasilibera*	
Goodeniaceae	*Goodenia* sp. (insufficient material)	
Goodeniaceae	*Goodenia wilunensis*	
Goodeniaceae	*Scaevola spinescens*	
Goodeniaceae	*Velleia glabrata*	
Gyrostemonaceae	*Codonocarpus cotinifolius*	
Gyrostemonaceae	*Gyrostemon ?tepperi*	
Haloragaceae	*Haloragis odontocarpa*	
Haloragaceae	*Haloragis* sp. (insufficient material)	
Haloragaceae	*Haloragis trigonocarpa*	
Hemerocallidaceae	*Dianella revoluta*	
Juncaginaceae	*Triglochin* sp. A Flora of Australia (G. J. Keighery 2477)	
Lamiaceae	*Dicrastylis brunnea*	
Lamiaceae	*Dicrastylis sessilifolia*	
Lamiaceae	*Hemigenia tomentosa*	
Lamiaceae	*Prostanthera albiflora*	

Family	Taxon	Status
Lamiaceae	*Prostanthera althoferi* subsp. *althoferi*	
Lamiaceae	*Prostanthera campbellii*	
Lamiaceae	*Prostanthera wilkieana*	
Lamiaceae	*Spartothamnella teucriiflora*	
Loranthaceae	*Amyema fitzgeraldii*	
Loranthaceae	*Amyema gibberula var. tatei*	
Loranthaceae	*Amyema hilliana*	
Loranthaceae	*Amyema nestor*	
Malvaceae	*Abutilon otocarpum*	
Malvaceae	*Abutilon oxycarpum*	
Malvaceae	*Abutilon* sp. (insufficient material)	
Malvaceae	*Alyogyne pinoniana*	
Malvaceae	*Androclava luteiflora*	
Malvaceae	*Hibiscus burtonii*	
Malvaceae	*Hibiscus* sp. Gardneri (A.L. Payne PRP 1435)	
Malvaceae	*Hibiscus sturtii* var. *truncatus*	
Malvaceae	*Keraudrenia velutina* subsp. *elliptica*	
Malvaceae	*Lawrencia ?squamata*	
Malvaceae	*Sida calyxhymenia*	
Malvaceae	*Sida ectogama*	
Malvaceae	*Sida fibulifera*	
Malvaceae	*Sida* sp. (insufficient material)	
Malvaceae	*Sida* sp. dark green fruits (S. van Leeuwen 2260)	
Malvaceae	*Sida* sp. Excedentifolia (J.L. Egan 1925)	
Malvaceae	*Sida* sp. Golden calyces glabrous (H.N. Foote 32)	
Malvaceae	*Sida* sp. verrucose glands (F.H. Mollemans 2423)	
Marsileaceae	*Marsilea hirsuta*	
Myrtaceae	*Aluta maisonneuvei*	
Myrtaceae	*Aluta aspera subsp. hesperia*	
Myrtaceae	*Aluta maisonneuvei* subsp. *articulata*	
Myrtaceae	*Calothamnus aridus*	
Myrtaceae	*Calytrix amethystina*	
Myrtaceae	*Calytrix carinata*	
Myrtaceae	*Calytrix erosipetala*	
Myrtaceae	*Calytrix uncinata*	Priority 3
Myrtaceae	*Calytrix verruculosa*	Priority 3
Myrtaceae	*Corymbia lenziana*	
Myrtaceae	*Enekbatus eremaeus*	
Myrtaceae	*Eucalyptus camaldulensis* subsp. *obtusa*	
Myrtaceae	*Eucalyptus camuldulensis*	
Myrtaceae	*Eucalyptus eremicola*	
Myrtaceae	*Eucalyptus eremicola* subsp. *peeneri*	
Myrtaceae	*Eucalyptus kingsmillii*	
Myrtaceae	*Eucalyptus lucasii*	

Family	Taxon	Status
Myrtaceae	*Eucalyptus socialus*	
Myrtaceae	*Homalocalyx echinulatus*	Priority 3
Myrtaceae	*Melaleuca xerophila*	
Myrtaceae	*Micromyrtus sulphurea*	
Nyctaginaceae	*Boerhavia repleta*	
Phrymaceae	*Peplidium* sp. C Evol. Fl. Fauna Arid Aust (N. T. Burbidge & A. Kanis 8158)	
Phyllanthaceae	*Sauropus ramosissimus*	Priority 3
Pittosporaceae	*Pittosporum angustifolium*	
Plantaginaceae	*Plantago* sp. (insufficient material)	
Poaceae	*Aristida contorta*	
Poaceae	*Aristida holathera*	
Poaceae	*Aristida inaequiglumis*	
Poaceae	*Austrostipa scabra*	
Poaceae	*Cenchrus ciliaris*	*
Poaceae	*Cymbopogon ambiguus*	
Poaceae	*Cymbopogon obtectus*	
Poaceae	*Digitaria brownii*	
Poaceae	*Enneapogon caerulescens*	
Poaceae	*Enneapogon* sp. (insufficient material)	
Poaceae	*Enteropogon ramosus*	
Poaceae	*Eragrostis dielsii*	
Poaceae	*Eragrostis eriopoda*	
Poaceae	*Eragrostis lacunaria*	
Poaceae	*Eragrostis lanipes*	
Poaceae	*Eragrostis pergracilis*	
Poaceae	*Eragrostis setifolia*	
Poaceae	*Eragrostis tenellula*	
Poaceae	*Eragrostis xerophila*	
Poaceae	*Eriachne benthamii*	
Poaceae	*Eriachne flaccida*	
Poaceae	*Eriachne helmsii*	
Poaceae	*Eriachne mucronata*	
Poaceae	*Eriachne pulchella* subsp. *dominii*	
Poaceae	*Eriachne* sp. (insufficient material)	
Poaceae	*Eulalia aurea*	
Poaceae	*Leptochloa fusca* subsp. *muelleri*	
Poaceae	*Monachather paradoxus*	
Poaceae	*Neurachne minor*	
Poaceae	*Paractaenum refractum*	
Poaceae	*Paraneurachne muelleri*	
Poaceae	*Paspalidium ?constrictum*	
Poaceae	*Setaria verticillata*	*
Poaceae	*Themeda triandra*	

Family	Taxon	Status
Poaceae	*Thyridolepis mitchelliana*	
Poaceae	*Thyridolepis multiculmis*	
Poaceae	*Triodia basedowii*	
Poaceae	*Triodia concinna*	
Poaceae	*Triodia melvillei*	
Poaceae	*Triodia* sp. (insufficient material)	
Poaceae	*Tripogon loliiformis*	
Polygonaceae	*Acetosa vesicaria*	*
Portulacaceae	*Calandrinia polyandra*	
Portulacaceae	*Calandrinia schistorhiza*	
Portulacaceae	*Calandrinia* sp. (insufficient material)	
Primulaceae	*Lysimachia arvensis*	*
Primulaceae	*Samolus repens*	
Proteaceae	*Grevillea berryana*	
Proteaceae	*Grevillea juncifolia*	
Proteaceae	*Grevillea juncifolia* subsp. *juncifolia*	
Proteaceae	*Grevillea sarissa*	
Proteaceae	*Grevillea sarissa* subsp. *succincta*	
Proteaceae	*Grevillea striata*	
Proteaceae	*Hakea leucopteris* subsp. *sericeps*	
Proteaceae	*Hakea lorea*	
Proteaceae	*Hakea preissii*	
Proteaceae	*Hakea recurva*	
Pteridaceae	*Cheilanthes brownii*	
Pteridaceae	*Cheilanthes lasiophylla*	
Pteridaceae	*Cheilanthes sieberi*	
Rhamnaceae	*Stenanthemum petraeum*	
Rubiaceae	*Psydrax latifolia*	
Rubiaceae	*Psydrax rigidula*	
Rubiaceae	*Psydrax suaveolens*	
Rubiaceae	*Synaptantha tillaeacea* var. *tillaeacea*	
Santalaceae	*Anthobolus leptomerioides*	
Santalaceae	*Santalum acuminatum*	
Santalaceae	*Santalum lanceolatum*	
Santalaceae	*Santalum spicatum*	
Sapindaceae	*Dodonaea microzyga*	
Sapindaceae	*Dodonaea pachyneura*	
Sapindaceae	*Dodonaea petiolaris*	
Sapindaceae	*Dodonaea viscosa* subsp. *spatulata*	
Scrophulariaceae	*Eremophila clarkei*	
Scrophulariaceae	*Eremophila congesta*	Priority 1
Scrophulariaceae	*Eremophila demissa*	
Scrophulariaceae	*Eremophila enata*	
Scrophulariaceae	*Eremophila eriocalyx*	

Family	Taxon	Status
Scrophulariaceae	*Eremophila exilifolia*	
Scrophulariaceae	*Eremophila falcata*	
Scrophulariaceae	*Eremophila flabellata*	
Scrophulariaceae	*Eremophila forrestii* subsp. *forrestii*	
Scrophulariaceae	*Eremophila forrestii* subsp. *hastieana*	
Scrophulariaceae	*Eremophila fraseri*	
Scrophulariaceae	*Eremophila fraseri* subsp. *fraseri*	
Scrophulariaceae	*Eremophila georgei*	
Scrophulariaceae	*Eremophila gilesii*	
Scrophulariaceae	*Eremophila gilesii* subsp. *gilesii*	
Scrophulariaceae	*Eremophila gilesii* subsp. *variabilis*	
Scrophulariaceae	*Eremophila glutinosa*	
Scrophulariaceae	*Eremophila hygrophana*	
Scrophulariaceae	*Eremophila jucunda* subsp. *jucunda*	
Scrophulariaceae	*Eremophila lachnocalyx*	
Scrophulariaceae	*Eremophila latrobei*	
Scrophulariaceae	*Eremophila latrobei* subsp. *glabra*	
Scrophulariaceae	*Eremophila latrobei* subsp. *latrobei*	
Scrophulariaceae	*Eremophila linearis*	
Scrophulariaceae	*Eremophila longifolia*	
Scrophulariaceae	*Eremophila macmillaniana*	
Scrophulariaceae	*Eremophila maculata* subsp. *brevifolia*	
Scrophulariaceae	*Eremophila malacoides*	
Scrophulariaceae	*Eremophila margarethae*	
Scrophulariaceae	*Eremophila oppositifolia* subsp. *angustifolia*	
Scrophulariaceae	*Eremophila platycalyx* subsp. *platycalyx*	
Scrophulariaceae	*Eremophila punctata*	
Scrophulariaceae	*Eremophila shonae* subsp. *shonae*	
Scrophulariaceae	*Eremophila simulans*	
Scrophulariaceae	*Eremophila* sp. (insufficient material)	
Scrophulariaceae	*Eremophila spathulata*	
Scrophulariaceae	*Eremophila spectabilis* subsp. *brevis*	
Scrophulariaceae	*Eremophila spectabilis* subsp. *spectabilis*	
Scrophulariaceae	*Eremophila spuria*	
Solanaceae	*Nicotiana cavicola*	
Solanaceae	*Nicotiana* sp. (insufficient material)	
Solanaceae	*Solanum ashbyae*	
Solanaceae	*Solanum cleistogamum*	
Solanaceae	*Solanum lasiophyllum*	
Solanaceae	*Solanum nummularium*	
Solanaceae	*Solanum* sp. (insufficient material)	
Stylidiaceae	*Stylidium longibracteatum*	
Thymelaeaceae	*Pimelea microcephala*	
Thymelaeaceae	*Pimelea trichostachya*	

Family	Taxon	Status
Zygophyllaceae	*Tribulus suberosus*	
Zygophyllaceae	*Zygophyllum aurantiacum*	
Zygophyllaceae	*Zygophyllum* sp. (insufficient material)	
Zygophylllaceae	*Zygophyllum iodocarpum*	

* introduced species

Table D.2 Definitions for flora likelihood of occurrence assessment

Likelihood of occurrence	Definition
Known	Species definitely recorded within the Survey Area from field survey results.
Likely	Species previously recorded within or adjacent to the Survey Area and suitable habitat occurs in the Survey Area.
Possible	Species previously recorded within 10 km with suitable habitat occurring in the Survey Area. OR Species not previously recorded within 10 km, but suitable habitat occurs in the Survey Area.
Unlikely	Species previously recorded within 10 km, but suitable habitat does not occur in the Survey Area.
Highly unlikely	Species not previously recorded within 10 km, suitable habitat does not occur in the Survey Area and/or Survey Area is outside the natural distribution of the species.

Table D.3 Aspects of assessment of efficacy of survey

Aspect	Detail
Intensity of the field survey.	Whether the whole/majority of the Survey Area was traversed.
	Whether the Survey Area was assessed in accordance with a Level 1 (reconnaissance) or Level 2 (detailed) survey.
Ease of identification of the species.	Whether the species is small and cryptic or large and easily noticeable.
	Whether the species was flowering at the time of the survey (many species cannot be identified without appropriate flowering material).

Table D.4 Flora likelihood of occurrence assessment for conservation significant flora

Family	Taxon	Status		Description and closest record information (if available) (WA Herbarium 1998–; DotE 2013)	Efficacy of field survey	Likelihood of occurrence	Source
		EPBC Act	WC Act/ DPaW				
Amaranthaceae	*Ptilotus chrysocomus*		P1	Compact, perennial, woody shrub, to one metre high, leaves bunched at shoots, oblanceolate, three to 10 mm long, 0.5 to one mm long; spikes yellow, ovoid-orbicular, six to 12 mm long, six to 10 mm wide; bracts 0.8 to one mm long; bracteoles 1.8 to 2.2 mm long; tepals 3.4 to four mm long; five fertile stamens; ovary glabrous, style 1.4 to 1.8 mm long, sigmoid, centrally fixed to ovary. Flowers yellow, Aug to Sep. Brown sandy clays. Bases of breakaways, rocky scree slopes. Closest record: Lake Way station, 28 km SE of Wiluna	Moderate	Possible – the species has been recorded in the general area and there is a small amount of suitable habitat present within the Survey Area.	NM
Amaranthaceae	*Ptilotus lazaridis*		P3	Herb or shrub, to 0.6 m high. Flowers pink/red, Jul or Oct. Clay loam. Floodplains Closest record: Paroo station, seven km north of Goldfields Highway	Moderate	Likely – the species has been recorded within 10 km of the Survey Area and there is suitable habitat present within the Survey Area.	NM
Amaranthaceae	*Ptilotus luteolus*		P3	Compact, woody subshrub, 0.2 to 0.3 m high, 0.3 to 0.4 cm wide. Flowers green/yellow, June, Aug-Sep. Lithosol, orange/brown/red clay loam, sandy soils. Rock platforms, near river channel, gravelly slopes. Closest record: three km north of Wiluna (2004)	Moderate	Known – the species was recorded during the GHD field survey.	NM, TPFL, WAHERB

Family	Taxon	Status		Description and closest record information (if available) (WA Herbarium 1998–; DotE 2013)	Efficacy of field survey	Likelihood of occurrence	Source
		EPBC Act	WC Act/ DPaW				
Asteraceae	*Olearia mucronata*		P3	Densely branched, unpleasantly aromatic shrub, 0.6 to one metre high. Flowers white & yellow, Aug to Dec or Jan. Schistose hills, along drainage channels.	Moderate	Possible – the species has been recorded in the general area and there is suitable habitat present within the Survey Area.	NM
Brassicaceae	*Menkea draboides*		P3	Prostrate, spreading annual, herb, to 0.6 m wide. Flowers white/cream, Aug to Sep. Red sand or clay, granite. Closest record: seven km north of Meekatharra.	Moderate	Likely – the species has been recorded within 10 km of the Survey Area and there is suitable habitat present within the Survey Area.	NM, TPFL, WAHERB
Celastraceae	*Stackhousia clementii*		P3	Dense broom-like perennial, herb, to 0.45 m high. Flowers green/yellow/brown. Skeletal soils. Sandstone hills.		Known – the species was recorded during the GHD field survey.	NM, WAHERB
Chenopodiaceae	*Maireana prosthecochaeta*		P3	Open, densely-leaved shrub, 0.3 to 0.6 m high. Laterite. Hills, salty places.	Moderate	Possible – the species has been recorded in the general area and there is suitable habitat present within the Survey Area.	NM
Chenopodiaceae	*Tecticornia cymbiformis*	V	P3	Erect, perennial shrub, 0.3 to 0.5 m high. Saline soils. Along the edge of creeklines	Moderate	Possible – the species has been recorded in the general area and there is suitable habitat present within the Survey Area.	NM
Colchicaceae	*Wurmbea sp. Denham Pool (F. Hort et al. 2216)*		P1	Erect, single stemmed plant to 0.15 m high. Flowers white/pink, Apr. Moist red sandy clay. Drainage line, flat, riverbank.	Moderate	Possible – the species has been recorded in the general area and there is suitable habitat present within the Survey Area.	NM

Family	Taxon	Status		Description and closest record information (if available) (WA Herbarium 1998–; DotE 2013)	Efficacy of field survey	Likelihood of occurrence	Source
		EPBC Act	WC Act/ DPaW				
Euphorbiaceae	*Beyeria lapidicola*		P1	Erect, straggly shrub, 0.6 to two metres high. Flowers green, Jul. Dry yellow/brown sandy loam over ironstone, red-orange sandy clay, fine gravel. Iron outcrop/ breakaway on midslopes of range, banded ironstone formation, dry creek bed.	Moderate	Possible – the species has been recorded in the general area and there is a small amount of suitable habitat present within the Survey Area.	NM
Fabaceae	*Acacia sclerosperma subsp. glaucescens*		P3	Spreading shrub, one to three metres high, branchlets puberulous, sometimes glabrous. Flowers yellow, Jul to Aug. Sand, sandy loam, stony soils.	Moderate	Likely – the species has been recorded in the area and there is suitable habitat present within the Survey Area.	NM
Fabaceae	*Acacia speckii*		P4	Bushy, rounded shrub or tree, 1.5 to three metres high. Rocky soils over granite, basalt or dolerite. Rocky hills or rises. Closest record: S of Meekatharra (c. 500 m south of the Survey Area) (1957).	Moderate	Possible – the species has been recorded within 10 km of the Survey Area and there is a small amount of suitable habitat present within the Survey Area.	NM, WAHERB
Fabaceae	*Indigofera sp. Gilesii (M.E. Trudgen 15869)*		P3	Spindly thorny shrub, one to two metres high. Flowers pink, red, May-Jun, Aug. Red/brown skeletal soils, ironstone pebbles/gravel, sandstone, granite. Gorge, gully, hilltop, creekline, sandplain.	Moderate	Possible – the species has been recorded in the general area and there is a small amount of suitable habitat present within the Survey Area.	NM
Fabaceae	*Mirbelia stipitata*		P3	Spiny shrub, ca 0.6 m high. Flowers Aug. Red sandy loam	Moderate	Possible – the species has been recorded in the general area and there is suitable habitat present within the Survey Area.	NM

Family	Taxon	Status		Description and closest record information (if available) (WA Herbarium 1998–; DotE 2013)	Efficacy of field survey	Likelihood of occurrence	Source
		EPBC Act	WC Act/ DPaW				
Goodeniaceae	*Goodenia berringbinensis*		P4	Ascending annual, herb, 0.1 to 0.3 m high. Flowers yellow, Oct. Red sandy loam. Along watercourses.	Moderate	Possible – the species has been recorded in the general area and there is suitable habitat present within the Survey Area.	NM
Lamiaceae	*Dicrastylis mitchellii*		P1	Shrub, to about 0.3 m high. Sand or clay soils. Around dunes. Closest record: 11 km north of the Survey Area (1981).	Moderate	Possible – the species has been recorded in the general area and there is a small amount of suitable habitat present within the Survey Area.	NM, WAHERB
Lamiaceae	*Hemigenia exilis*		P4	Erect, multi-stemmed shrub, 0.5 to two metres high. Flowers blue-purple/white, Apr or Sep to Nov. Laterite. Breakaways, slopes.	Moderate	Possible – the species has been recorded in the general area and there is suitable habitat present within the Survey Area.	MRWA
Lamiaceae	*Hemigenia virescens*		P3	Erect, compact shrub, 0.2 to 0.4 m high, 0.4 to 0.6 m wide. Fl, white, purple, Jul, Aug. Brown rocky sand, banded ironstone gravel, yellow/red sandy clay, shallow loam. Hillside, rangeland, sand banks.	Moderate	Possible – the species has been recorded in the general area and there is suitable habitat present within the Survey Area.	NM
Lamiaceae	*Pityrodia augustensis*	V	T	Bushy shrub, ca one metre high. Flowers purple/purple-red, Aug to Sep. Amongst rocks on slopes or in drainage lines. This species occurs in rocky hillsides in the Mt Augustus area. The closest record of this species is approximately 300 km north-west of the Survey Area.	Moderate	Unlikely – the Survey Area is outside the known range of this species.	EPBC

Family	Taxon	Status		Description and closest record information (if available) (WA Herbarium 1998–; DotE 2013)	Efficacy of field survey	Likelihood of occurrence	Source
		EPBC Act	WC Act/ DPaW				
Lamiaceae	*Prostanthera ferricola*		P3	Erect, openly-branched shrub, 0.3 to one metre high. Shallow red-brown skeletal sandy loam on banded ironstone, laterite, basalt or quartz. Gently inclined mid to upper slopes of hills, rocky crests, outcrops. Closest record 15 km south of the Survey Area (2008).	Moderate	Possible – the species has been recorded in the general area and there is a small amount of suitable habitat present within the Survey Area.	NM, WAHERB
Malvaceae	*Sida picklesiana*		P3	Shrub, 0.4-0.8 m high, 0.9 to one metre wide. Fl, yellow, Apr, Aug, Nov-Dec. Sandy loam with quartz and ironstone gravel, brown stony clay. Granite breakaway, upperslopes, ridge, edge of creekline.	Moderate	Possible – the species has been recorded in the general area and there is a small amount of suitable habitat present within the Survey Area.	NM
Myrtaceae	*Baeckea sp. Sandstone (C.A. Gardner s.n. 26 Oct. 1963)*		P3	Upright shrub, ca one metre high. Flowers white, Oct. Orange sand. Flats.	Moderate	Possible – the species has been recorded in the general area and there is suitable habitat present within the Survey Area.	NM
Myrtaceae	*Calytrix uncinata*		P3	Shrub, 0.3 to one metre high. Flowers white, Aug to Nov. White or red sand, sandy clay. Granite or sandstone breakaways, rocky rises. Closest record: three km north of the Survey Area.	Moderate	Known – the species was recorded during the GHD field survey.	NM, WAHERB
Myrtaceae	*Calytrix verruculosa*		P3	Shrub, 0.4 to 0.75 m high. Flowers pink/white, Aug or Oct. Sandy clay. Closest record: Yoothapina Station, c. 15 km NNW of Meekatharra (1986)	Moderate	Possible – the species has been recorded in the general area and there is suitable habitat present within the Survey Area.	NM, TPFL, WAHERB

Family	Taxon	Status		Description and closest record information (if available) (WA Herbarium 1998–; DotE 2013)	Efficacy of field survey	Likelihood of occurrence	Source
		EPBC Act	WC Act/ DPaW				
Myrtaceae	*Euryomyrtus inflata*		P3	Shrub, 0.3 to 0.7 m high, leaves dull green, fruits erect. Flowers white-pink, Jun to Jul. Deep red sand. Flat plain. Closest record: 13 km south of the Survey Area.	Moderate	Possible – the species has been recorded in the general area and there is suitable habitat present within the Survey Area.	NM, WAHERB
Myrtaceae	*Homalocalyx echinulatus*		P3	Shrub, 0.45 to one metre high. Flowers pink, Jun to Sep. Laterite. Breakaways, sandstone hills.	Moderate	Possible – the species has been recorded in the general area and there is a small amount of suitable habitat present within the Survey Area.	NM, WAHERB
Poaceae	*Neurachne lanigera*		P1	Tufted perennial, grass-like or herb, 0.15-0.3 m high. Flowers other, Jul to Aug or Oct. Red sand, laterite. Rocky outcrops, plains.	Moderate	Possible – the species has been recorded in the general area and there is suitable habitat present within the Survey Area.	NM
Polygalaceae	*Comesperma viscidulum*		P4	Shrub, to ca 0.7 m high. Yellow sand, loam, gravel, red sand. Dune, flat, high in landscape, gently undulating terrain, sandstone breakaway.	Moderate	Possible – the species has been recorded in the general area and there is a small amount of suitable habitat present within the Survey Area.	MRWA
Proteaceae	*Grevillea inconspicua*		P4	Intricately branched, spreading shrub, 0.6 to two metres high. Flowers white/pink-white, Jun to Aug. Loam, gravel. Along drainage lines on rocky outcrops, creeklines. Closest record: Meekatharra airport (1990).	Moderate	Likely – the species has been recorded within 10 km of the Survey Area and there is suitable habitat present within the Survey Area.	NM, TPFL, WAHERB

Family	Taxon	Status		Description and closest record information (if available) (WA Herbarium 1998–; DotE 2013)	Efficacy of field survey	Likelihood of occurrence	Source
		EPBC Act	WC Act/ DPaW				
Rhamnaceae	*Stenanthemum mediale*		P1	Erect shrub, ca 0.35 m high, leaves entire. Flowers Apr to Aug. Red clayey sand.	Moderate	Possible – the species has been recorded in the general area and there is suitable habitat present within the Survey Area.	MRWA
Rutaceae	*Drummondita miniata*		P3	Divaricately branched shrub, 0.5 to two metres high. Flowers orange-red, Jul to Aug or Nov. Laterite. Breakaways. Closest record: two km east of Meekatharra (2003).	Moderate	Likely – the species has been recorded within 10 km of the Survey Area and there is suitable habitat present within the Survey Area.	NM, WAHERB
Scrophulariaceae	*Eremophila anomala*		P1	Shrub. Flowers white, Aug to Sep. Basalt outcrop.	Moderate	Unlikely – the species has been recorded in the general area, but a there is no suitable habitat present within the Survey Area.	NM
Scrophulariaceae	*Eremophila arguta*		P1	Perennial, prostrate shrub, 0.3 m high, 0.5 m wide. Flowers purple, blue, May, Nov. Brown sand. Floodplain, road verge, limestone rise, creek.	Moderate	Possible – the species has been recorded in the general area and there is a small amount of suitable habitat present within the Survey Area.	MRWA
Scrophulariaceae	*Eremophila congesta*		P1	Upright shrub, to 1.2 m high. Flowers purple-blue, Aug to Sep. Lateritic outcrops in greenstone hills, stony quartzite slopes. Closest record: 2.5 km N of Goldfields Hwy (2005).	Moderate	Known – the species was recorded during the GHD field survey.	NM, TPFL, WAHERB

Family	Taxon	Status		Description and closest record information (if available) (WA Herbarium 1998–; DotE 2013)	Efficacy of field survey	Likelihood of occurrence	Source
		EPBC Act	WC Act/ DPaW				
Scrophulariaceae	*Eremophila fasciata*		P3	Erect shrub, 0.6 to 0.9 m high. Flowers blue-violet, Aug. Stony hill. Closest record: one km south of the Survey Area (1961)	Moderate	Likely – the species has been recorded in the area and there is suitable habitat present within the Survey Area.	NM, WAHERB
Scrophulariaceae	*Eremophila gracillima*		P3	Low flat shrub, ca 0.3 m high, 1.2 m wide. Flowers blue, Sep. Stony flats.	Moderate	Possible – the species has been recorded in the general area and there is suitable habitat present within the Survey Area	MRWA
Scrophulariaceae	*Eremophila retropila*		P1	Spreading shrub, 0.7 to 1.7 m high, to 4.2 m wide. Flowers purple-red-white, Aug to Sep. Gravelly loam. Stony flats. Closest record: 3.5 km S of Meekatharra (2001)	Moderate	Likely – the species has been recorded in the area and there is suitable habitat present within the Survey Area.	NM, TPFL, WAHERB
Zygophyllaceae	*Tribulus adelacanthus*		P3	Prostrate herb, plants villous; leaflet pairs three to six; fruits 5-winged, lacking spines, 10 to 14 mm high. BIF and haematite outcrop. Closest record: 15 km S of the Survey Area (2006).	Moderate	Possible – the species has been recorded in the general area and there is a small amount of suitable habitat present within the Survey Area.	NM, WAHERB

Legend:

V	Vulnerable
P	Priority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
WC Act	*Wildlife Conservation Act 1950*
DPaW	Department of Parks and Wildlife
MRWA	Main Roads Western Australia

Sources: TPFL (DPaW); EPBC (DotE 2013e); NM - Naturemap (DPaW 2007–); WAHERB (DPaW); MRWA (data supplied by MRWA)

Refer to Appendix A for conservation code descriptions.

Appendix E – Desktop PEC report

Subterranean Ecology
Scientific Environmental Services

Goldfields Highway
Wiluna - Meekatharra Upgrade
Groundwater Calcrete Assemblages
Desktop Assessment

Prepared for

Department of Main Roads Western Australia

21 May 2014

GOLDFIELDS HIGHWAY
WILUNA - MEEKATHARRA UPGRADE
GROUNDWATER CALCRETE ASSEMBLAGES
DESKTOP ASSESSMENT

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Report No. 2014/04
Prepared for
Main Roads Western Australia
21 May 2014

COVER: Blind diving beetle, endemic to groundwater calcrete in the Goldfields. Photo © Subterranean Ecology 2013.

LIMITATIONS: This survey was limited to the requirements specified by the client and the extent of information made available to the consultant at the time of undertaking the work. Information not made available to this study, or which subsequently becomes available may alter the conclusions made herein.

VERSION	PREPARED BY	REVIEWED BY	RECIPIENT	DATE
Ver. 1	S. Eberhard		Emma Fitzgerald DMRWA	21 May 2014

EXECUTIVE SUMMARY

This desktop assessment was commissioned by the Department of Main Roads Western Australia (DMRWA) to provide a desktop assessment of Calcrete Groundwater Assemblages (CGA's) that may be impacted by the upgrade of the Goldfields Highway from Wiluna to Meekatharra (185 kilometres).

The upgrade works will involve the widening (between 6 - 25 metres), raising (approximately 600mm) and sealing of the currently unsealed highway, and some minor realignments. The proposed works will require the draw of groundwater from a network of existing and new bores, and the extraction of road building materials (i.e. sand and gravel) to a maximum depth of 5 metres. Approximately 55 gravel pits will be developed in the local area, approximately 5 hectares each.

The scope of this report is to provide advice on the following questions:

1. Are the mapped extent of known CGA's accurate?
2. Are there potentially other CGA's in the study area?
3. What is the significance of these CGA's in the local, regional, state and national context?
4. Is the project likely to have an impact on these CGA's?
5. Would this impact be considered significant by the Environmental Protection Authority (EPA) under Environmental Protection Act 1986 (EP Act) or by Department of Sustainability, Environment, Water, Population and Community (DSEWPAC) under the Environmental Protection Biodiversity Conservation Act 1999 (EPBC Act) ?
6. The project will require the draw of groundwater from a network of existing and new bores. What distance should be applied to avoid impacts to the CGA's;
7. What management actions are recommended to avoid, reduce and manage potential impacts to CGA's ?

The main context and findings were:

Calcrete Groundwater Assemblages (CGA's) are the ecological community or assemblage of subterranean invertebrates (typically stygofauna) that inhabit groundwater in calcrete.

Seventy-four (74) CGA's in the northern Yilgarn are listed as Priority Ecological Communities (PEC's) (Priority 1) by the Department of Parks and Wildlife (DPaW). Thirty (30) of these listed PEC's occur within DMRWA's defined study area, of which three (Killara, Paroo, and Millbillillie Bubble Well) may be directly influenced by the highway upgrade.

Numerous additional calcrete deposits occur within the study area, and these very likely harbor CGA's that would qualify for listing as Priority 1 PEC's. Some of these calcretes may also be influenced by the highway upgrade and associated works (gravel pits and groundwater pumping).

1. Mapping Reliability

The mapped extent of known CGA's cannot be assumed to be accurate. While the 'accuracy' of mapped extent of known CGA's is likely to be reasonable in terms of general location of calcrete bodies, the mapping may be imprecise with respect to definition of boundaries. The likelihood that additional small and/or obscured CGA's lie undetected in the study area cannot be precluded.

2. Additional CGA's in the study area

A desktop review of available geology maps identified at least 19 additional calcrete deposits (or deposit clusters) which are not recognised as CGA's, or listed as PEC's. The locations of additional calcrete deposits are documented in this report.

3. Significance of CGA's

The CGA's in the study area are significant at all scales, from local to regional, state, national and global.

4. Potential Impacts

A suite of potential direct and indirect impacts to CGA's are considered in relation to the highway upgrade and associated works, however all of these can be avoided, managed and mitigated to ensure that the Project does not pose an unacceptable risk to conservation of CGA's.

5. Significance of Potential Impacts

There is a low likelihood that the highway upgrade and associated works will pose a significant threat to CGA's subject to the following conditions:

1. Groundwater pumping or drawdown will not impinge on any CGA's or other calcrete deposits.
2. Gravel pits will be located to avoid CGA's and other calcrete deposits.
3. Best practice operational procedures are applied to avoid and manage potential impacts to groundwater recharge and groundwater quality, that might result from road building activities on or near to CGA's including drainage, gravel pits and control of leakage / spills.

Environmental Management and Mitigation Recommendations

1. Groundwater pumping will be located so as to avoid all CGA's and calcrete deposits.
2. Groundwater pumping operations will be managed to ensure that a minimum 2000 m buffer of zero drawdown is maintained between any calcrete deposit and the maximum limit of drawdown propagation from a groundwater pumping station.
3. Modelling of the lateral extent of drawdown propagation will be undertaken as required to ensure 2000 m buffer (of zero drawdown) separation from any calcrete..
4. Gravel pits will be located at least 500m away from CGA's or any calcrete deposit.
5. The design of highway drainage should aim to maintain, so far as practicable, natural hydrological processes (run-off, infiltration, groundwater recharge) and water quality.

6. During highway works, best practice environmental management procedures pertaining to hydrocarbons and any other potentially harmful substances should be applied, including procedures for management of leakages and spills.
7. Where there is a likelihood that a CGA or other calcrete deposit may be affected by the highway works then it is recommended that field inspection by a suitably qualified person (geologist, hydrogeologist or groundwater ecologist) be undertaken to confirm that sites selected for groundwater pumping and gravel pits are located to avoid calcrete.

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1 INTRODUCTION

Project Description

This report was commissioned by the Department of Main Roads Western Australia (DMRWA) to provide a desktop assessment of Calcrete Groundwater Assemblages (CGA's) that may be impacted by the upgrade of the Goldfields Highway from Wiluna to Meekatharra (185 kilometres).

The upgrade works will involve the widening (between 6 - 25 metres), raising (approximately 600mm) and sealing of the currently unsealed highway. There are some minor realignments and one of these may be located on a CGA.

The proposed works will require the draw of groundwater from a network of existing and new bores, and the extraction of road building materials (i.e. sand and gravel) to a maximum depth of 5 metres. Approximately 55 road building materials pits will be developed in the local area, approximately 5 hectares each. The gravel pits and groundwater pumping will be located so as to avoid all CGA's.

Culverts and floodway's will be utilised where the road traverses ephemeral creek lines or areas subject to inundation. The proposed works are not expected to negatively impact upon surface water regimes and is expected to facilitate a more natural flow (i.e. rate and direction) of surface water than the current road design.

Scope

The scope of this desktop assessment is to provide advice on the following questions, as specified in the brief from DMRWA (via email from J. Johnston) and reproduced below:

1. Are the mapped extent of known CGA's accurate?
2. Are there potentially other CGA's in the study area?
3. What is the significance of these CGA's in the local, regional, state and national context?
4. Is the project likely to have an impact on these CGA's?
5. Would this impact be considered significant by the Environmental Protection Authority (EPA) under Environmental Protection Act 1986 (EP Act) or by Department of Sustainability, Environment, Water, Population and Community (DSEWPAC) under the Environmental Protection Biodiversity Conservation Act 1999 (EPBC Act) ?
6. The project will require the draw of groundwater from a network of existing and new bores. What distance should be applied to avoid impacts to the CGA's;
7. What management actions are recommended to avoid, reduce and manage potential impacts to CGA's ?

2 METHODS

Legislation and Policy Guidelines

This assessment was prepared with consideration to the following State and Federal legislation and relevant assessment guidelines:

- *Environmental Protection Act 1986* (*EP Act 1986*) (WA).
- Environmental Protection Authority (2013) Environmental Assessment Guideline for consideration of subterranean fauna in environmental impact assessment in Western Australia. EAG No. 12. Environmental Protection Authority, Western Australia, June 2013.
- *Environment Protection and Biodiversity Conservation Act 1999.*
- Department of the Environment, Water, Heritage and the Arts (DEWHA) (2009) Matters of National Environmental Significance: Significant Impact Guidelines 1.1.
- Threatened Species Scientific Committee (TSSC) (2012) National Threatened Ecological Community Strategic Workshop, 8 – 9 March 2012, Canberra.

Information Sources

The following site-specific information sources were used in this assessment:

- Geological Survey of Western Australia (GSWA) maps – 1:250,000 and 1:100,000 series.
- GSWA Hydrogeology map Western Australia – 1:2,500,000 (Commander 1989).
- Western Australian Museum specimen database search northern Yilgarn region.
- Published scientific literature.

3 DEFINITIONS

Terms

Most of the following definitions are from Department of Parks and Wildlife web page on threatened ecological communities <www.dpaw.wa.gov.au/>

An **assemblage** is a defined group of biological entities.

Ecological Community - A naturally occurring biological assemblage that occurs in a particular type of habitat.

Threatening processes are defined as follows:
"Any process or activity that threatens to destroy or significantly modify the ecological community and/or affect the continuing evolutionary processes within any ecological community."

Definitions of Modification and Destruction of an ecological community:

Modification: "changes to some or all of ecological processes (including abiotic processes such as hydrology), species composition and community structure as a direct or indirect result of human activities. The level of damage involved could be ameliorated naturally or by human intervention."

Destruction: "modification such that reestablishment of ecological processes, species composition and community structure within the range of variability exhibited by the original community is unlikely within the foreseeable future even with positive human intervention."

A **threatened ecological community (TEC)** is one which is found to fit into one of the following categories; "presumed totally destroyed", "critically endangered", "endangered" or "vulnerable".

The Minister for Environment may list an ecological community as being threatened if it is presumed to be, or is at risk of becoming, totally destroyed.

"Possible threatened ecological communities that do not meet survey criteria are added to DPaW's **Priority Ecological Community (PEC)** Lists under Priorities 1, 2 and 3.

Calcrete Groundwater Assemblage (CGA) – Unique assemblage of subterranean invertebrates (stygofauna) inhabiting groundwater in calcrete.

Stygofauna are aquatic subterranean fauna that inhabit groundwater in both the saturated and unsaturated zones.

Troglofauna are air-breathing terrestrial subterranean fauna that inhabit the unsaturated zone of aquifers above the watertable and below the soil layer.

Threatened Ecological Communities (TECs)

The department of Parks and Wildlife (ex DEC) has been identifying and informally listing **threatened ecological communities (TECs)** since 1994.

As of March 2013, 367 ecological communities had been entered into the TEC database.

- The WA Minister for Environment has endorsed 69 of these:
  - 21 critically endangered
  - 17 endangered
  - 28 vulnerable
  - 3 presumed totally destroyed.
- 23 of these TECs are also listed under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999*.

Note: None of the above listed TEC's are Calcrete Groundwater Assemblages and therefore do not require further consideration in relation to this Project scope.

- The remaining 297 ecological communities are allocated to one of five priority categories (**priority ecological communities**).

Ecological communities with insufficient information available to be considered a TEC, or which are rare but not currently threatened, are placed on the Priority list and referred to as **priority ecological communities (PEC's)**.

Priority Ecological Communities (PECs)

Possible threatened ecological communities that do not meet survey criteria or that are not adequately defined are added to the Priority Ecological Community List under priorities 1, 2 and 3. These three categories are ranked in order of priority for survey and/or definition of the community, and evaluation of conservation status, so that consideration can be given to their declaration as threatened ecological communities. Ecological communities that are adequately known, and are rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list, are placed in Priority 4. These ecological communities require regular monitoring. Conservation Dependent ecological communities are placed in Priority 5.

Note: All Calcrete Groundwater Assemblages are treated as Priority 1 PECs.

Priority 1 PEC's

Priority 1 PEC's are poorly-known ecological communities. Priority 1 PEC's are defined as:

"Ecological communities that are known from very few occurrences with a very restricted distribution (generally ≤5 occurrences or a total area of ≤ 100ha). Occurrences are believed to be under threat either due to limited extent, or being on lands under immediate threat (e.g. within agricultural or pastoral lands, urban areas, active mineral leases) or for which current threats exist. May include

communities with occurrences on protected lands. Communities may be included if they are comparatively well-known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range."

4 POLICY & STATUTORY CONTEXT

In Western Australia, the Environmental Protection Authority (EPA) has legislative responsibility to protect the environment and to prevent, control and abate pollution and environmental harm. The EPA fulfils these duties in part by conducting environmental impact assessment (EIA) of major projects and providing independent advice to Government on whether the environmental risks and impacts can be managed. The EPA has developed a series of Guidance Statements for the EIA of major projects including guidance statements specifically for subterranean fauna (EPA 2003, 2007, 2012).

In the last two decades subterranean fauna has become prominent as a key environmental factor in around 40 major project assessments in Western Australia (EPA 2012). Most of these EIA's have related to mining projects in the mineral-rich regions of the Pilbara and Yilgarn. In accordance with the *Wildlife Conservation Act 1950* and the *Environmental Protection Act 1986*, the EPA 'will ensure that proposals do not potentially threaten the viability of any subterranean species' and 'ensure adequate protection of important habitats for these species' (EPA 2003).

Environmental Protection Act 1986

"The Environmental Protection Act 1986 (the Act) provides for the referral and environmental impact assessment (EIA) of proposals and schemes likely, if implemented, to have a significant effect on the environment. The EPA uses environmental factors and associated objectives as the basis for assessing whether a proposal or scheme's impact on the environment is acceptable. They therefore underpin the EIA process."

Environmental Assessment Guidelines

"Environmental Assessment Guidelines (EAGs) – formerly Guidance Statements – are issued by the EPA to provide advice to proponents and the public generally on the procedures and minimum environmental requirements that the EPA expects to be met during the environmental impact assessment process.

EAGs are not statutory documents. However, a proponent wishing to deviate from the minimum level of performance set out in an EAG would be expected to put a well-researched and clear justification to the EPA arguing the need for the deviation. An argument to deviate from the requirements in an EAG should demonstrate that all practicable endeavours have been made to meet the intent of the Guideline."

EAG No. 8 Environmental factors and objectives

"This guideline sets out the EPA's environmental factors and associated objectives for the purposes of EIA. An environmental factor is described as the part of the environment that may be impacted by an aspect of the proposal. The related environmental objective for each factor is the desired goal that, if met, will indicate that the proposal is not expected to have a significant impact on the environment."

EAG No. 9 Application of a significance framework in the EIA process

"The EPA applies a Significance Framework to make decisions through the environmental impact assessment process, based on the concept of significance established under the Environmental Protection Act 1986. The likely significance of impacts in relation to meeting the EPA's environmental objectives for each key environmental factor will be the focus of the EIA process."

"Key environmental factors are those factors where the EPA's objectives may be met, but where there is a (current) lack of confidence, signifying the need for more information or conditions related to implementation (including, if necessary, offsets).

If there is early confidence that none of the factors are key environmental factors, the proposal will not be assessed by the EPA. As soon as there is confidence that a factor is not a key environmental factor, that factor will receive no further consideration by the EPA."

EAG No. 11 Recommending environmental conditions

The EPA may consider that conditions are required for particular factors so they are adequately mitigated to meet the environmental objective (that is, to bring the proposal below the significance threshold), and will recommend conditions accordingly.

EAG No. 12 Subterranean fauna

EAG No. 12, finalised and released 30 June 2013, sets out the EPA's preferred approach for the consideration of subterranean fauna in environmental impact assessment. It aims to ensure that the standard of survey and type of information provided to the EPA have a sound scientific basis to enable it to understand impacts. This EAG supersedes Guidance Statement No. 54 (EPA 2003) however Draft Guidance Statement 54a (EPA 2007a) is still used to provide information on sampling techniques.

Environmental Protection & Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act) is the Australian Government's central piece of environmental legislation. It provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places — defined in the EPBC Act as matters of national environmental significance. Under the EPBC

Act an action will require approval from the minister if the action has, will have, or is likely to have, a significant impact on a matter of national environmental significance.

Note: None of the CGA's listed as PEC's by DPaW are listed threatened ecological communities (or species) under the EPBC Act. This does not mean that these CGA's would not qualify for listing as a TEC under the EPBC Act if a proposed 'action' posed a 'significant impact'.

The Significant Impact Guidelines 1.1 (DEWHA 2009) for matters of National Significance (EPBC Act 1999), state the following:

What are matters of national environmental significance?

"The matters of national environmental significance are:

- *listed threatened species and ecological communities*
- *migratory species protected under international agreements*
- *Ramsar wetlands of international importance*
- *the Commonwealth marine environment*
- *World Heritage properties*
- *National Heritage places*
- *Great Barrier Reef Marine Park, and*
- *nuclear actions.*

A person who proposes to take an action that will have, or is likely to have, a significant impact on a matter of national environmental significance must refer that action to the minister for a decision on whether assessment and approval is required under the EPBC Act."

What is an action?

'Action' is defined broadly in the EPBC Act and includes: a project, a development, an undertaking, an activity or a series of activities, or an alteration of any of these things.

Actions include, but are not limited to: construction, expansion, alteration or demolition of buildings, structures, infrastructure or facilities; industrial processes; mineral and petroleum resource exploration and extraction; storage or transport of hazardous materials; waste disposal; earthworks; impoundment, extraction and diversion of water; agricultural activities; aquaculture; research activities; vegetation clearance; culling of animals; and dealings with land.

Actions encompass site preparation and construction, operation and maintenance, and closure and completion stages of a project, as well as alterations or modifications to existing infrastructure.

An action may have both beneficial and adverse impacts on the environment, however only adverse impacts on matters of national environmental significance are relevant when determining whether approval is required under the EPBC Act."

What is a significant impact?

"A 'significant impact' is an impact which is important, notable, or of consequence, having regard to its context or intensity. Whether or not an action is likely to have a significant impact depends upon the sensitivity, value, and quality of the environment which is impacted, and upon the intensity, duration, magnitude and geographic extent of the impacts."

Potential Impacts Subterranean Fauna

The EPA's (2013) EAG No. 12 states that impacts on (subterranean) fauna may be direct or indirect. Direct impacts include the removal, disturbance or compaction of habitat or water quality changes. Indirect impacts include changes to hydrology, siltation, alteration to nutrient balance (EPA 2013). The likely degree of the impact can be determined from a series of characteristics including the proportion and extent of habitat removal, duration of impact, effects on water quality and hydrology, and degree of ecological isolation if contiguous habitat is interrupted. Depending on the proportion of the geological feature containing the troglofauna habitat proposed to be extracted, the degree of impact would be moderate to high (EPA 2013).

Examples of impact types include (from EAG No. 12; EPA 2013,):

- *Excavation of rock*
- *Groundwater extraction/dewatering (single bore/bore-field)*
- *Groundwater reinjection*
- *Changed surface topography due to compaction or creation of hard surfaces resulting in altered groundwater flow paths and increased runoff and reduced infiltration and aquifer recharge*
- *Potential leaks resulting in alterations to ground water quality including waste water, introduction of toxins or radiation*
- *Salinization due to pit voids or intrusion*
- *Vegetation clearing - leading to sedimentation and changed nutrient inputs.*

Impact Assessment Subterranean Fauna

The EPA's (2013) EAG No. 12 for subterranean fauna does not provide criteria for ranking the degree of impact as either 'low', 'moderate', 'high' (ie. significant) , but it does recommend that justification of measures used to define the scale for each characteristic should be outlined, and should be based on the unique impacts of a proposal.

The EPA's EAG No. 12 further states:

> *"For example the degree of impact to stygofauna is likely to be low where the project impact is only above ground. Examples of groundwater abstraction on stygofauna could range from a single bore impacting on a relatively large aquifer to a series of bores impacting on a similar sized aquifer. In the former, if the duration was short and the spatial extent was low, the degree of impact would be low. In the latter, if the duration was long, the spatial extent was moderate or high and the level of water drawdown was several metres, the degree of impact would be high. Excavation or mining of rock would impact permanently on troglofauna. Depending on the proportion of the geological feature containing the troglofauna habitat proposed to be excavated, the overall degree of impact would be moderate to high."*

5 GROUNDWATER CALCRETES

In the semi-arid northern Yilgarn craton there occur numerous (> 100) isolated groundwater calcretes developed along palaeoriver systems (Morgan 1993, Mann and Horwitz 1996) (Figure 1). Development of these calcretes was initiated during dry climatic conditions in the Oligocene and has continued during subsequent arid phases of the Late Miocene and Pliocene onwards (Morgan 1993). The calcrete aquifers have a well-developed karstic porosity and therefore provide an ideal habitat for stygofauna.

The mapped distribution of groundwater calcretes in the northern Yilgarn is shown in Figure 1. Around 200 major calcretes are shown on the 1:2,500,000 GSWA hydrogeological map (Commander 1989). Many more smaller calcretes are shown on the finer-scale 1:250,000 and 1:100,000 GSWA maps.

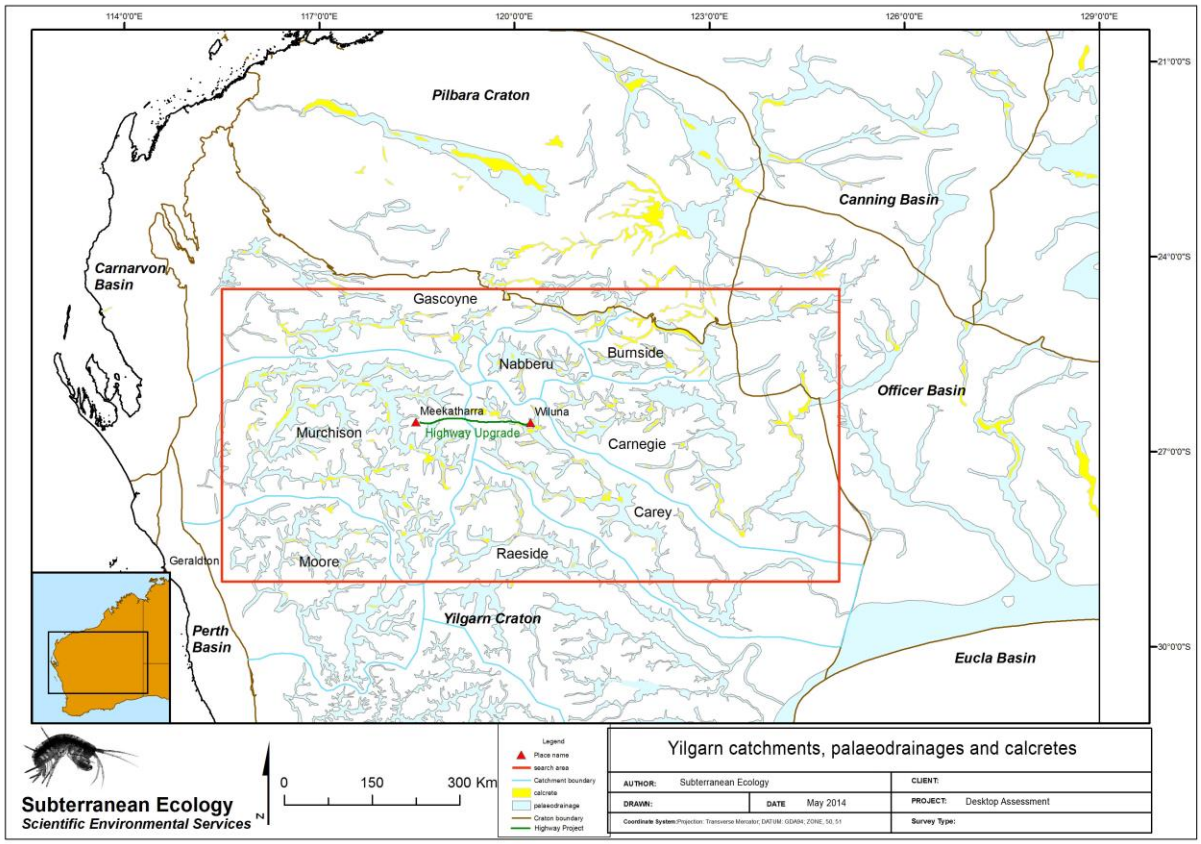

Figure 1 Yilgarn and Pilbara cratons showing palaeodrainages and calcrete deposits, Yilgarn palaeoriver catchments, stygofauna data search area boundary (red) and Wiluna – Meekatharra Highway (green). Hydrogeology adapted from Commander (1989).

6 CALCRETE GROUNDWATER ASSEMBLAGES (CGA's)

The term Calcrete Groundwater Assemblage (CGA) refers to the ecological community or assemblage of subterranean invertebrates (typically stygofauna) that inhabit groundwater in calcrete.

Groundwater of (semi-) arid Western Australia is becoming known as a globally significant hotspot for subterranean biodiversity (Humphreys 2008, Eberhard *et al.* 2009, Guzik *et al.* 2011). Most of this rich diversity has only been discovered in the last 15 years in two main geographic regions, the Pilbara craton and the northern Yilgarn craton (Figure 1).

In the northern Yilgarn each calcrete aquifer functions as a hydrogeological 'island' (Cooper et al. 2002, 2008); and many species of stygofauna are locally endemic to a single calcrete, or a few geographically proximal calcretes (Leys and Watts 2008). Each calcrete 'island' or proximal cluster of islands typically harbors a unique assemblage of species considered to represent a 'type' of Calcrete Groundwater Assemblage (CGA).

The CGA's in the Yilgarn calcretes harbor many species of stygofauna including dytiscid diving beetles (Cooper et al. 2002; Leys et al. 2003) and numerous crustaceans, including amphipods (Cooper et al. 2007; Bradford et al. 2010), isopods (Cooper et al. 2008), ostracods (Karanovic and Marmonier 2002; Karanovic 2004, 2006), parabathynellids (Guzik et al. 2008), and copepods (De Laurentiis et al. 2001; Karanovic and Cooper 2011, 2012).

More recently, troglofauna have also been found in the Yilgarn calcretes. They have been less-studied than stygofauna, but similarly comprise unique assemblages of troglobitic arthropods including palpigrades (Barranco and Harvey 2008), pseudoscorpions (Edward and Harvey 2008) and spiders (Platnick 2008) for example. Their concordant occurrence within groundwater calcretes suggests that troglofauna should also be considered as comprising an element within a CGA.

CGA's in the northern Yilgarn

Review of the published scientific literature and collation with results from the WA Museum database search revealed subterranean fauna records from 68 groundwater calcretes in the northern Yilgarn (Figure 2).

Note: Many additional calcretes have not been sampled for stygofauna, however it can be assumed with a high degree of confidence that any calcrete body that intersects permanent groundwater is likely to harbor a CGA, and, that the stygofauna / troglofauna assemblage is likely to include short range endemic species of conservation significance.

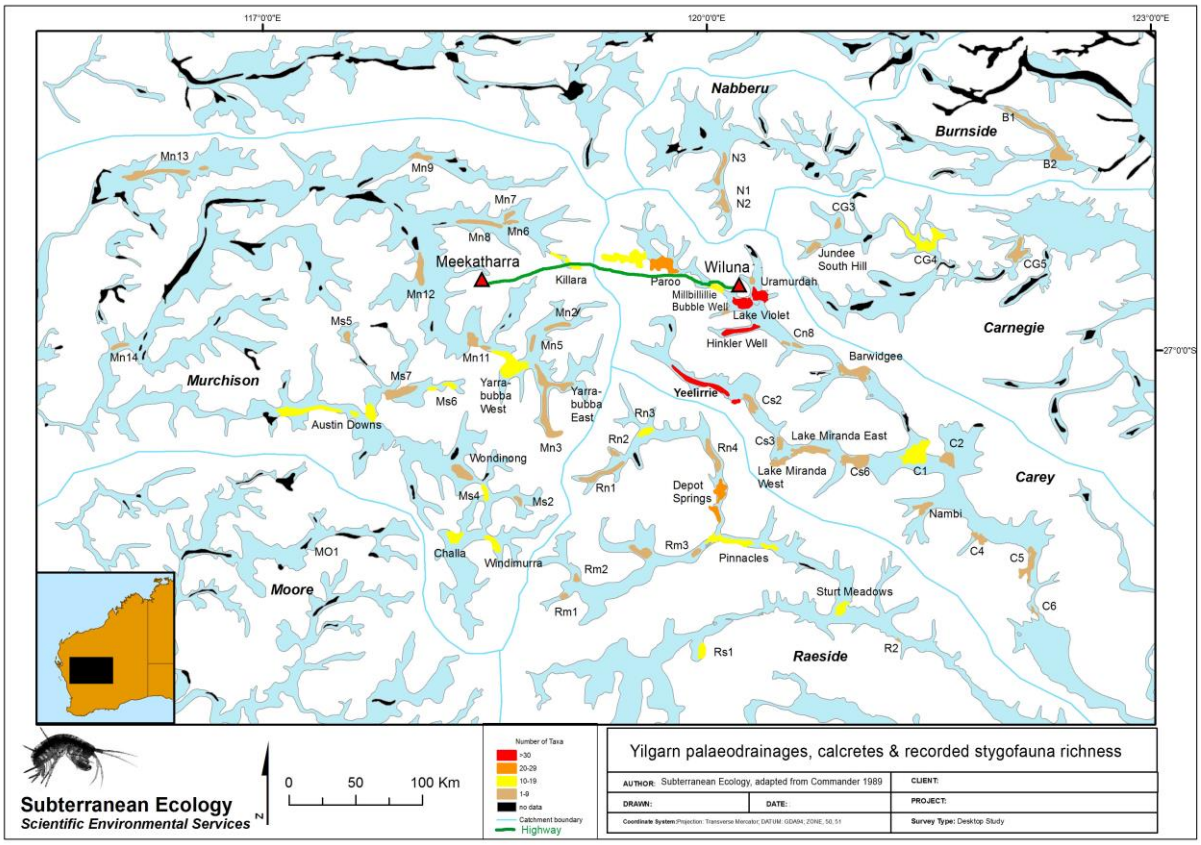

Figure 2 Northern Yilgarn stygofauna records search area showing palaeodrainages and calcrete deposits, palaeoriver catchments, and Wiluna – Meekatharra Highway (green). Hydrogeology adapted from Commander (1989).

CGA's listed as PEC's

Seventy-four (74) CGA's in the northern Yilgarn are listed as PEC's (Priority 1) by DPaW (version 19, September 2013). Each of these PEC's are identified by a unique name (eg. Millbillillie Bubble Well Calcrete) and all carry the same generic description - "unique assemblage of invertebrates." Similarly, for all these PEC's the identified threat is "mining". This of course does not preclude other potential threats from non-mining activities including this Project.

Thirty (30) listed CGA PEC's occur within DMRWA's defined study area which extends for approximately 50 km of the Wiluna-Meekatharra Highway (Table 1). Three of these listed PEC's are relevant to this project. These are the Killara, Paroo, and Millbillillie Bubble Well CGA's.

Note: Numerous additional calcretes occur within the study area, and these very likely also harbor CGA's that would qualify for listing as Priority 1 PEC's. These have not been listed as PEC's by DPaW because they have not been sampled for stygofauna. These additional calcretes and potential CGA's are identified later in this report.

Table 1. Listed CGA PEC's on DPaW database located within approximately 50 km of the Wiluna-Meekatharra Highway (data provided by DMRWA). Three calcretes of particular relevance to this project are highlighted in bold.

Name	Priority	Buffer (m)	Approx. Area (Ha)
Killara Calcrete	Priority 1	2000	5,219
Paroo Calcrete	Priority 1	2000	14,547
Millbillillie Bubble Well Calcrete	Priority 1	2000	2,107
Doolgunna Calcrete	Priority 1	2000	1,922
Hillview Calcrete	Priority 1	2000	2,451
Murchison Calcrete	Priority 1	2000	4,249
Hinkler Well Calcrete	Priority 1	2000	7,322
Kaluwiri Calcrete	Priority 1	2000	4,710
Lake Way South Calcrete	Priority 1	2000	1,706
Milgun Central Calcrete	Priority 1	2000	2,303
Milgun South Calcrete	Priority 1	2000	219
Mount Padbury Calcrete	Priority 1	2000	4,016
Old Cunyu Calcrete	Priority 1	2000	6,424
Polelle Calcrete	Priority 1	2000	6,007
Three Rivers Calcrete	Priority 1	2000	269
Three Rivers Plutonic Calcrete	Priority 1	2000	26,958
Yeelirrie Calcrete	Priority 1	2000	17,691
Belele Calcrete	Priority 1	2000	10,769
Albion Downs Calcrete	Priority 1	2000	4,085
Cunyu Calcrete	Priority 1	2000	8,625
Killara North Calcrete	Priority 1	2000	2,110
Karalundi Calcrete	Priority 1	2000	1,090
Wiluna BF Calcrete	Priority 1	2000	232
Uramurdah Calcrete	Priority 1	2000	2,105
Lake Violet Calcrete	Priority 1	2000	3,211
Yarrabubba West Calcrete	Priority 1	2000	1,554
Nowthanna Calcrete	Priority 1	2000	5,307
Colga Calcrete	Priority 1	2000	7,948
Yarrabubba East Calcrete	Priority 1	2000	12,401
Mingah Springs Calcrete	Priority 1	2000	37

7 ASSESSMENT

Mapping Reliability

Is the mapped extent of known CGA's accurate?

The mapped extent of known CGA's cannot be assumed to be accurate. Moreover, reliability in mapping will vary between and within geological map sheets. While the 'accuracy' of mapped extent of known CGA's is likely to be reasonable in terms of general location of calcrete bodies, the mapping may be imprecise with respect to definition of boundaries. For example, there are significant discrepancies between the 1:250,000 and 1:100,000 scale geological maps in the mapped extent for many calcrete bodies, including the three CGA's of relevance to this project. This is not unusual and is to be expected with regard to the practicalities in geological survey.

For the major calcrete bodies depicted on the geological maps and those listed as PEC's, the mapped geological boundaries may be considered representative but cannot necessarily account for subsurface extensions or discontinuities, or completely buried calcrete deposits that exhibit no surface expression at all. It is possible, indeed likely, that small calcrete bodies, or larger calcrete bodies with little or no surface expression, remain undetected and undocumented. For purposes of this assessment, the locations and areas of occupation of calcrete bodies may be treated as broadly indicative, but a precautionary approach is recommended with respect to boundary definition. It is noted that DPaW's list of CGA PEC's (Table 1) provides an estimate of each calcrete area (ha) but also applies a 2000m buffer around each.

The likelihood that additional small and/or obscured CGA's lie undetected in the study area cannot be precluded. Indeed, this is likely. This uncertainty can be managed by taking a precautionary approach and planning for this contingency in operational procedures (see mitigation options later).

Additional unlisted CGA's

Are there potentially other CGA's in the study area?

In the study area there are at least 19 additional calcrete deposits (or deposit clusters) shown on the geology maps which are not recognised as CGA's or listed as PEC's. It can be assumed with a high degree of confidence that any calcrete body that intersects permanent groundwater is likely to harbor a CGA and therefore qualify as a PEC Priority 1.

These additional calcrete deposits are not listed as PEC's because they have not been sampled for subterranean fauna. They have not been sampled owing to the very large number of calcrete deposits throughout the Yilgarn, and the limited number of subterranean fauna surveys carried out to date. Many calcretes, or portions of calcretes, are not accessible for sampling if there are no water bores or

pastoral wells present. Any calcrete deposits that intersect permanent groundwater are likely to harbor CGA's.

The listed PEC's and additional calcrete deposits shown on the geology maps are listed in Table 2 and also highlighted on the geology maps appended to this report. Many deposits are geographically clustered and clearly genetically related, and these clusters have been grouped together to avoid an inordinately lengthy list. The identified additional deposits have been assigned a provisional name based on their geographic location or a named nearby feature. It is possible, indeed likely, that small calcrete bodies, or larger calcrete bodies with little or no surface expression, remain undetected and undocumented on the geological maps.

For ease of interpretation, all mapped calcretes, including those shown on the 100k series maps but not shown on the 250k series, have been indicated on the two 250k series maps which cover the project area (Glengarry and Wiluna 1:250k sheets). The 100k series maps should also be referred to for more detailed locations and boundaries as required. There are five 100k maps covering the project area which are provided attached to this report but note that two additional 100k maps (Gabanintha and Yanganoo) relevant to this project area were not available on the DMP site (http://www.dmp.wa.gov.au/) so they may be out of print or unpublished.

Table 2 Additional calcretes and potential CGA's identified on 250k and 100k geological series maps (refer maps appended). Sites are listed approximately from west to east. Listed PECs are in bold.

Name	Description	250k geo sheet	100k geo sheets	Notes
Karalundi Calcrete	Karalundi calcrete groundwater assemblage type on Murchison palaeodrainage on Karalundi Station	Glengarry	Glengarry	
Cork Tree Bore	Two calcretes south of Karalundi Calcretes	Glengarry	Glengarry	
Holt Well (Bolt Well)	Calcretes east of Karalundi Calcretes	Glengarry	Glengarry	
Munarra	Small calcrete E of Munarra Homestead and SW of Deep Well	Glengarry	Glengarry	Not indicated on 100k
Glengarry Creek	Glengarry Creek 8 km S of Bolts (Holts) Well & 4 km NW Mistletoe Well	Glengarry	Glengarry	Not mapped on 250k
Talval	South of Talval Outcamp, NE of Limestone Well, south of Meekatharra	Glengarry	Gabanintha NA	
Limestone Well	SW of Talval Outcamp, south of Meekatharra	Glengarry	Gabanintha NA	
Hillview Calcrete	Hillview calcrete groundwater assemblage type on Murchison palaeodrainage on Hillview Station	Glengarry	Gabanintha NA	
Murchison Calcrete	Murchison Downs calcrete groundwater assemblage type on Murchison palaeodrainage on Murchison Downs Station	Glengarry	Gabanintha - Yaganoo NA	
Top Well	NE of Murchison Calcretes	Glengarry	Yaganoo NA	
Killara North Calcrete	Killara North calcrete groundwater assemblage types on Murchison palaeodrainage on Killara Station	Glengarry	Glengarry - Moologool	
Killara Calcrete	Killara calcrete groundwater assemblage types on Murchison palaeodrainage on Killara Station	Glengarry	Moologool	
Morrie Northwest	Small calcrete approx. 1.5 km NW of Morrie Bore	Glengarry	Moologool	
Morrie Bore	Small calcrete at Morrie Bore	Glengarry	Moologool	Not mapped on 250k
Morrie North	Small calcrete (?) approx. 2 km N of Morrie Bore Morrie Bore	Glengarry	Moologool	Mapped as siltstone on 100k
Large Gum Creek	Small calcrete on tributary of Large Gum Creek, N of Diamond Well Homestead	Glengarry	Mount Bartle	
Dura Bore	Small calcrete NE of Paroo Homestead	Glengarry	Mount Bartle	
Paroo West	Series of > 20 scattered calcrete deposits forming a western extension of main Paroo Calcrete, includes Limestone & White Wells, Rabbit, Meeks, Saltbush and Bobs Bores.	Glengarry	Moologool - Mount Bartle	
Paroo Calcrete	Paroo calcrete groundwater assemblage type on Carey palaeodrainage on Paroo Station	Glengarry	Mount Bartle	
Paroo Southwest	Two calcrete deposits southwest of main Paroo Calcrete	Glengarry	Mount Bartle	Not mapped on 250k

Paroo Southeast	Six calcrete deposits comprising southeast extension of main Paroo Calcrete	Glengarry	Mount Bartle	Not mapped on 250k
Mount Bartle	Four calcrete deposits between Mount Bartle and Mount Russell	Glengarry	Mount Bartle-Merewether	Not mapped on 250k
Yandil	Mutliple calcrete clusters north and east of Yandil Homestead	Glengarry	Mount Bartle	Not mapped on 250k
Gum Creek	Small calcrete north of Millbillillie Bubble Well Calcrete	Glengarry - Wiluna	Mount Bartle - Wiluna	Not shown Glengarry 250k
Bellah Bore	Small calcrete west of Mt Merewether	Glengarry	Merewether	
Millbillillie Bubble Well Calcrete	Millbillillie Bubble Well groundwater calcrete assemblage type on Carey palaeodrainage on Millbillillie Station	Glengarry - Wiluna	Merewether - Wiluna	
Uramurdah Calcrete	Uramurdah Lake calcrete groundwater assemblage type on Carey palaeodrainage on Millbillillie Station	Wiluna	Wiluna	
Lake Violet Calcrete	Lake Violet south and Lake Violet calcrete groundwater assemblage types on Carey palaeodrainage on Millbillillie Station	Wiluna	Wiluna	
Hinkler Well Calcrete	Hinkler Well calcrete groundwater assemblage type on Carey palaeodrainage on Lake Way Station	Wiluna	Wiluna	

Significance of CGA's

What is the significance of these CGA's in the local, regional, state and national context?

The CGA's in the study area are significant at all scales, from local to regional, state, national and global.

Each CGA has local significance because it contains a unique assemblage of invertebrates, including species that are locally endemic to each calcrete.

Collectively, the CGA's have regional significance because each calcrete 'island' with its unique invertebrate assemblage comprise an element making up an 'archipelago' which collectively represent a significant component of Western Australia's subterranean biodiversity.

At national levels, the richness and significance of the Yilgarn CGA's has only been recognized over the last decade or so, but has led to them being recognised as a globally significant biodiversity hotspot for stygofauna (Culver and Pipan 2009).

The high conservation significance of the CGA's is exemplified by the blind diving beetles of the family Dytiscidae. More than 100 species of dytiscid diving beetles have been described from calcrete aquifers throughout the Yilgarn, representing the highest stygal diversity of this group in the world. The calcrete island distribution pattern is replicated in other stygofauna groups (e.g. syncarids, amphipods, isopods), with the majority of species being SRE, restricted to single (or proximal) calcrete aquifers (Bradford *et al*. 2010; Cooper *et al*. 2002, 2007, 2008; Guzik *et al*. 2008, 2009; Humphreys 2001, 2006, 2008, Humphreys *et al*. 2009; Watts and Humphreys 1999, 2000, 2001, 2003, 2004, 2006, Leys *et al*. 2003).

More recently, troglofauna have been discovered in the Yilgarn calcretes, including, for example, a species of spider (Platnick 2008), a pseudoscorpion (Edward and Harvey 2008), and the first Australian native species of palpigrade (Barranco and Harvey 2008). All of these species are currently known from single calcretes and are likely to include short range endemic (SRE) species.

Potential Impacts

Is the project likely to have an impact on CGA's?

Based on the EPA's (2013) EAG for consideration of subterranean fauna in environmental impact assessment in Western Australia, the potential direct and indirect impacts relevant to CGA's and considered in regard to this Project are listed below with project-specific qualifications [underlined in square brackets]:

- Excavation of rock / gravel [only if on calcrete].
- Groundwater extraction/dewatering [single bore/bore-field if affecting calcrete aquifer].
- Changed surface topography due to compaction or creation of hard [impermeable road] surfaces resulting in increased runoff and reduced infiltration and aquifer recharge [or modified infiltration / recharge regime].
- Potential leaks [or sediment-laden runoff] resulting in alterations to ground water quality including waste water, introduction of toxins or radiation [eg. hydrocarbon spills, sediments]
- Salinization due to pit voids or intrusion [if gravel pits extend below watertable in or near calcrete]
- Vegetation clearing [road drainage and runoff] - leading to sedimentation and changed nutrient inputs [only when on or near calcrete].

While there exist a diverse suite of potential impacts, all of these can be avoided, managed and mitigated to ensure that the Project does not pose an unacceptable risk to conservation of CGA's. Management and mitigation measures are outlined in a later section.

Significance of Potential Impacts

Would any potential impacts be considered significant by the EPA under EP Act 1986 or by DSEWPAC under the EPBC Act 1999?

The EPA's (2013) EAG No. 12 for subterranean fauna does not provide criteria for ranking the degree of impact as either 'low', 'moderate', 'high' (ie. significant) , but it does recommend that justification of measures used to define the scale for each characteristic should be outlined, and should be based on the unique impacts of a proposal.

To address the question - 'Would the impact of this Project be considered significant by the EPA under EP Act 1986 or by DSEWPAC under the EPBC Act 1999? – the EPBC Act listing criteria for assessing TECs (Threatened Species Scientific Committee 2012) were tested against the situation evidence for this Project (Table 3).

Table 3 suggests that there is no existing evidence and a low likelihood that the proposed Project actions will pose a threat to CGA's subject to the following key assumptions / mitigation measures:

4. Groundwater pumping or drawdown will not impinge on any CGA's.
5. Best practice operational procedures are applied to avoid and manage potential impacts to groundwater recharge and groundwater quality, that might result from road building activities on or near to CGA's including drainage, gravel pits and control of leakage / spills.

Table 3 Evaluation of Project against EPBC Act listing criteria for assessing Threatened Ecological Communities (TSSC 2012). Note key assumptions at bottom (continued overleaf).

Criterion		EPBC Act Category			Goldfields Highway Upgrade Project		
		Critically Endangered	Endangered	Vulnerable	Situation / Evidence	Assumptions /Comments	* Meets Criteria for TEC listing?
1	Its decline in geographic distribution is:	very severe > 95%	severe > 90%	substantial > 70%	No evidence and low likelihood that proposed actions will cause a decline in geographic distribution if assumptions are true*	*Assumes groundwater pumping or drawdown impacts will not affect any CGA's.	No
2	Its geographic distribution is: and the nature of its distribution makes it likely that the action of a threatening process could cause it to be lost in:	very restricted the immediate future	restricted the near future	limited the medium-term future	Geographic distribution of CGA's is very restricted but No evidence and low likelihood that proposed actions will pose a threat if assumptions are true*	*Assumes groundwater pumping or drawdown impacts will not affect any CGA's.	No
3	For a population of a native species that is likely to play a major role in the community, there is a: to the extent that restoration of the community is not likely to be possible in:	very severe decline the immediate future	severe decline the near future	substantial decline the medium-term future	No declines documented and low likelihood that proposed actions will pose a threat if assumptions are true*	*Assumes groundwater pumping or drawdown impacts will not affect any CGA's.	No
4	The reduction in its integrity across most of its geographic distribution is: as indicated by degradation of the community or its habitat, or disruption of important community processes, that is:	very severe very severe	severe severe	substantial substantial	No degradation of community, habitat or processes documented, and low likelihood that proposed actions will pose a threat if assumptions are true*	*Assumes groundwater pumping or drawdown impacts will not affect any CGA's. *Assumes best practice operational procedures are applied to avoid and manage potential impacts to groundwater quality that might result from road building activities on or near to CGA's, including drainage, gravel pits and control of leakage / spills.	No

5	Its rate of continuing detrimental change is: as indicated by: (a) rate of continuing decline in its geographic distribution, or a population of a native species that is believed to play a major role in the community, that is: or (b) intensification, across most of its geographic distribution, in degradation, or disruption of important community processes, that is:	very severe very severe very severe	severe severe severe	substantial serious serious	No detrimental changes documented, and low likelihood that proposed actions will pose a threat if assumptions are true*	*Assumes groundwater pumping or drawdown impacts will not affect any CGA's. *Assumes best practice operational procedures are applied to avoid and manage potential impacts to groundwater quality that might result from road building activities on or near to CGA's, including drainage, gravel pits and control of leakage / spills.	No
6	A quantitative analysis shows that its probability of extinction, or extreme degradation over all of its geographic distribution, is:	at least 50% in the immediate future	at least 20% in the near future	at least 10% in the medium-term future	Quantitative analysis not attempted.	Insufficient data for reliable quantitative analysis.	N/A

Notes:
Species in the extinct and conservation dependant categories of species listed under the EPBC Act, and listed ecological communities in the vulnerable category of ecological communities listed under the EPBC Act, are not matters of national environmental significance for the purposes of Part 3 of the EPBC Act (requirements for environmental approvals).

Species and ecological communities listed under the EPBC Act may differ from those listed under State and Territory legislation. This is due to the different status of some species and ecological communities in the different States and Territories, and nationally.

*** Key Assumptions:**
*Assumes groundwater pumping or drawdown impacts will not affect any CGA's.
* Best practice operational procedures are applied to avoid and manage potential impacts to groundwater quality that might result from road building activities on or near to CGA's, including drainage, gravel pits and control of leakage / spills.

8 ENVIRONMENTAL MANAGEMENT & MITIGATION

8.1 Environmental Management Objectives

The environmental factors and objectives adopted by the EPA (EAG No. 8) which are relevant to this Project and scope are listed in Table 4.

While the scope of this report is primarily focused on subterranean fauna the importance of **hydrological processes** and **water quality** to maintain the habitat and environmental conditions for subterranean fauna is emphasised.

Recommendation:

It is recommended that the EPA's Management Objectives for relevant environmental factors (Table 4) be adopted for CGA's and this Project.

Table 4 Environmental factors and management objectives for subterranean fauna, hydrological processes and water quality. From EPA (EAG No. 8).

Environmental factor	Management Objective
Subterranean Fauna	To maintain representation, diversity, viability and ecological function at the species, population and assemblage level.
Hydrological Processes	To maintain the hydrological regimes of groundwater and surface water so that existing and potential uses, including ecosystem maintenance, are protected.
Inland Waters Environmental Quality	To maintain the quality of groundwater and surface water, sediment and biota so that the environmental values, both ecological and social, are protected.

8.2 Site selection for groundwater pumping and gravel pits

Because of uncertainties in geological mapping and imprecisely defined boundaries for many CGA's, and the likelihood of encountering different boundaries to those shown on geology maps, and the additional possibility of discovering new calcrete deposits, these scenarios should be considered and planned for in operational procedures.

Where there is a likelihood that a CGA or other calcrete deposit may be affected by the Project then it is recommended that field inspection by a suitably qualified person (geologist / hydrogeologist / groundwater ecologist) be undertaken to confirm that sites selected (via desktop) for groundwater pumping and gravel pits are located to avoid calcrete.

It is recommended that DMRWA document the location and relevant boundaries of any calcrete deposits within 2000 m of Project operations and to report these (with locations mapped) to DPaW.

8.3 Buffers

For most of the listed Priority 1 PEC's, including those relevant to this project, the 2000m buffer zone prescribed by DPaW is a default precautionary distance and probably adequate for reducing the risk of unintentionally impinging upon a known CGA. This buffer distance might potentially be reduced if the boundaries of the CGA are accurately known and depending upon the nature and magnitude of potential impacts occurring within the buffer zone.

For example a gravel pit that does not intersect calcrete or the watertable is unlikely to pose a significant threat to CGA's, and in this case a 500m buffer should be adequate. It is noted that for other types of listed PEC in the study area, namely banded ironstone formation vegetation complexes (Wiluna West, Montague Range) and the invertebrate assemblages of Mibbley Pool, a 500m buffer is prescribed by DPaW. On the other hand, if pumping of groundwater might result in watertable drawdown extending for more 2000 m then a wider buffer zone would be required for any CGA's in the proximity.

Conceptual buffers are indicated in Figure 3.

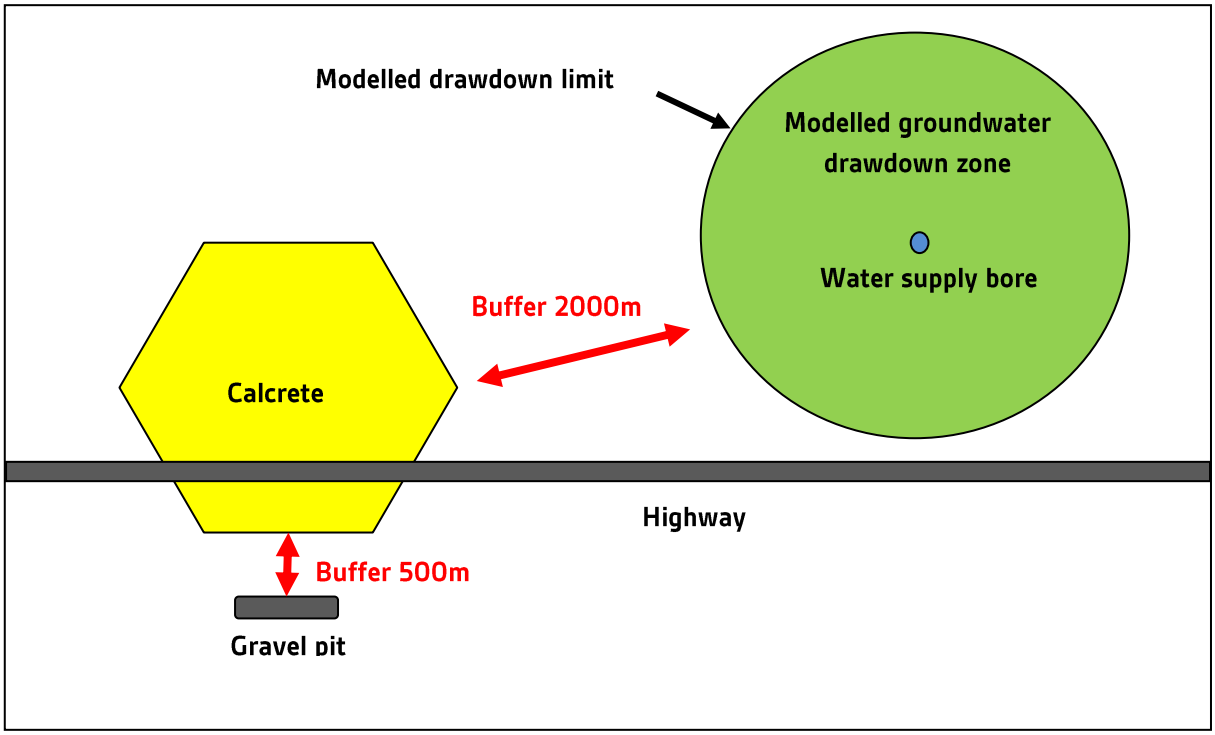

Figure 3 Conceptual buffers for groundwater pumping and gravel pits.

8.4 Groundwater Pumping

What distance should be applied to avoid groundwater drawdown impacts to the CGA's from the network of existing and new bores?

Because the calcrete aquifers and CGA's are typically shallow and have a narrow depth range (often extending only a few metres or tens of metres below watertable) they are vulnerable to desaturation from pumping of groundwater. While CGA's may be tolerant of partial temporary desaturation (assuming rapid watertable recovery), a precautionary approach is recommended owing to the uncertainty of this impact.

Hence, if there is any risk that groundwater drawdown may impinge on a known CGA or other calcrete deposit, then modelling of the lateral extent of groundwater drawdown propagation based on the pumping rate and local aquifer properties may be required to determine an acceptable precautionary distance of separation.

Recommendations:

1. Groundwater pumping will be located so as to avoid all CGA's and calcrete deposits.
2. Groundwater pumping operations will be managed to ensure that a minimum 2000 m buffer of zero drawdown is maintained between any calcrete deposit and the maximum limit of drawdown propagation from a groundwater pump (Figure 3).
3. Modelling of the lateral extent of drawdown propagation will be undertaken as required to ensure 2000 m buffer (of zero drawdown) separation from any calcrete.

8.5 Gravel pits:

Gravel pits that do not intersect calcrete or the watertable are unlikely to pose a significant threat to CGA's, and in this situation a 500m buffer should be adequate.

Where there is a likelihood that a CGA or other calcrete deposit may be affected by gravel pits then it is recommended that field inspection by a suitably qualified person (geologist / hydrogeologist / groundwater ecologist) be undertaken to confirm that sites selected for gravel pits are located to avoid calcrete.

Recommendations:

4. Gravel pits will be located so as to avoid all known (and potential) CGA's.
5. Gravel pits will be located at least 500m away from any calcrete deposit (Figure 3).

8.6 Highway Works:

Recommendations:

6. The design of highway drainage should aim to maintain, so far as practicable, natural hydrological processes (run-off, infiltration, groundwater recharge) and water quality.
7. During highway works, best practice environmental management procedures pertaining to hydrocarbons and any other potentially harmful substances should be applied, including procedures for management of leakages and spills.

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10 APPENDICES

Geology maps and calcrete deposits

Geological Survey of Western Australia (Glengarry and Wiluna 1:250,000 sheets with identified calcrete deposits marked (cross-referenced in Table 2).

Geological Survey of Western Australia 1:100,000 series. For reference.

Refer separate pdf files appended to this report.

GLENGARRY

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

AUSTRALIA 1 : 250 000 GEOLOGICAL SERIES

SHEET SG 50 - 12

SYMBOLS

Geological boundary
Fault
- Accurate
- Inferred
Fold
- Syncline
- Minor fold showing plunge
- Pseudotic fold (sense of asymmetry indicated), showing plunge
Bedding
- Inclined
- Vertical
- Horizontal
- Air photo interpretation of bedding
  - Dip <5°
  - Dip 5° - 15°
  - Dip 15° - 45°
- Trend line
Foliation, primary igneous
- Inclined
- Vertical
- Trend
Foliation, gneissic banding
- Inclined
- Vertical
Foliation, metamorphic
- Inclined
- Vertical
Regional foliation, in granite
Cleavage
- Inclined
- Vertical
Lineation, metamorphic
- Showing plunge
- Horizontal
Facing indicated by
- Graded bedding
- Pillow structures
Shear zone
Air photo lineament
Stromatolite locality

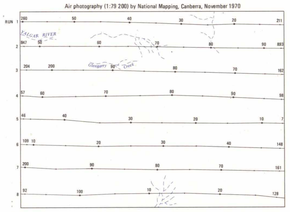
Goldfield boundary
Highway with national route marker
Formed road
Track
Townsite (gazetted,population < 1000) — Portlel
Homestead — Munarra
Building
Locality — Yerganon
Horizontal control, major, minor
Bench mark, height accurate — PY 83 48.4
Airport
Landing ground
Breakaway
Sand dune

Watercourse intermittent
Well — W
Bore — B
Windpump
Spring — S
Pool
Waterhole — WH
Rockhole — RH
Abandoned — (abd)
Position doubtful — (PD)

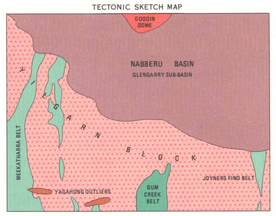
MISTLETOE
Mining centre
Mine, may or may not be working — Bourke Find
(gold unless otherwise indicated)
Open cut mine or quarry, may or may not be working
(gold unless otherwise indicated)
Prospect
Mineral occurrence
- Building stone — Bs
- Copper — Cu
- Gold — Au
- Graphite — Gt
- Iron — Fe
- Lithium — Li
- Magnesite — Ms
- Titanium — Ti
- Vanadium — V

FLIGHT DIAGRAM

Air photography (1:79 200) by National Mapping, Canberra, November 1970



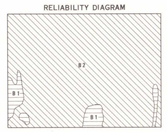
TECTONIC SKETCH MAP



Compiled and published by the Geological Survey of Western Australia. Cartography by the Geological Mapping Section, Department of Minds. Topographic base from compilations by the Department of Lands and Surveys.

Copies of this map may be obtained from the Geological Survey of Western Australia, 66 Adelaide Tce., Perth.

RELIABILITY DIAGRAM



B1 Numerous traverses with air photo interpretation

B2 Air photo interpretation with a few traverses

HON. P.V. JONES, M.L.A.
MINISTER FOR MINES

A.F. TRENDALL, DIRECTOR, GEOLOGICAL SURVEY

SCALE 1 : 250 000

5 0 5 10 15 20 25 30 Kilometres

TRANSVERSE MERCATOR PROJECTION
ZONE 50 AUSTRALIAN MAP GRID

INDEX TO ADJOINING SHEETS

ROBINSON RANGE SG 50 - 7	PEAK HILL SG 50 - 8	NABBERU SG 51 - 5
BELELE SG 50 - 11	GLENGARRY SG 50 - 12	WILUNA SG 51 - 9
CUE SG 50 - 15	SANDSTONE SG 50 - 16	SIR SAMUEL SG 51 - 13

Geology by : J.A. Bunting 1976-77, D.F. Commander 1976, M. Elias and P.W. Wharton 1977.

DECLINATION DIAGRAM

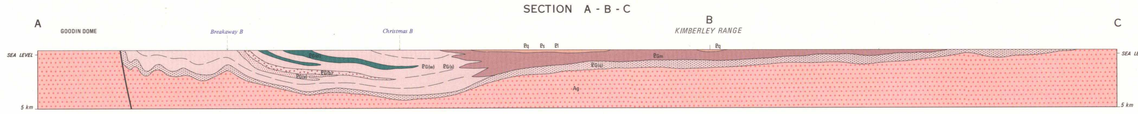
The lines indicate magnetic declination, 1976. To convert magnetic bearing to true bearing, to be added in compass bearing to give true bearing. - means declination is east and correction must be subtracted from compass bearing to give true bearing.

Annual change is -1° westerly

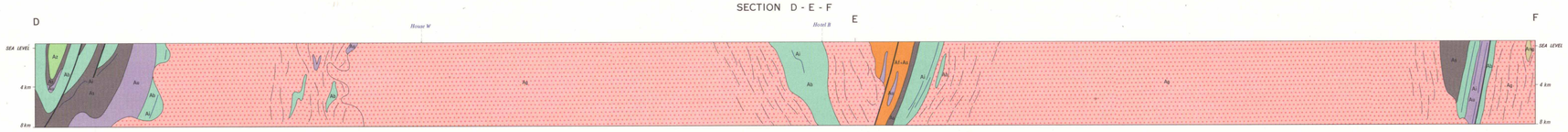
DIAGRAMMATIC SECTIONS

NATURAL SCALE

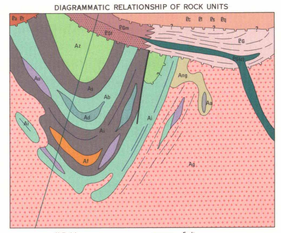
SECTION A - B - C



SECTION D - E - F



DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS



Mafic dyke — Fault

Unconformity — Trend Line : bedding foliation trace

REFERENCE

CAINOZOIC — QUATERNARY

Qa Eolian sand in dunes and sheets, red-brown
Qc Colluvium, quartz and rock fragments in loam, unconsolidated, grades into Qz
Qz Colluvium and alluvium, red brown sandy and clayey loam as sheetwash deposits, grades into Qa
Qa Alluvium, unconsolidated sand, silt and gravel in drainage lines and adjacent flood plains

TERTIARY

Czl Laterite, massive and pisolitic ferruginous duricrust; in places contains relict structures of parent rock
Czb Silcrete, siliceous duricrust with angular quartz grains, over granitoid rock
Czj Ferruginous siliceous capping over ultramafic rock ; brown to orange-brown
Czv Deeply weathered, kaolinized rock, may be subsequently ferruginized and silicified
Czk Valley calcrete, sheet carbonate with minor chalcedony in lines of ancient drainage

PRECAMBRIAN

Age variable and/or uncertain

Veins and dykes

q Quartz
p Pegmatite; feldspar and mica altered to pale green fine-grained muscovite
p Pegmatite, predominantly quartz-feldspar
g Granitoid
Dl Dolerite
Dlm Dolerite, metamorphosed

Glengarry Group

Ph Chert, chert breccia, silicified carbonate
Pl Limestone, marl; stromatolitic
Ps Shale, marl
Pq Quartz arenite, intraclastic conglomerate, minor shale
Pa Lithic arenite, arkose, greywacke, minor shale and pebbly beds
Pc Conglomerate, rounded clasts in lithic and arkosic matrix, polymict, minor lithic arenite and arkose

Mt Yagahong area

Dolerite sill

EARLY PROTEROZOIC

Pbla Chert, chert breccia
Pdla Limestone, dolostone, minor shale
Pbla Shale, minor sandstone
Pdwa Quartz wacke, lithic wacke, shale
Pdaa Arkosic sandstone, minor shale
Pdba Basalt, minor intermediate volcanic rocks
Pdga Quartz arenite, minor conglomerate and shale

Pdm MARALOOU FORMATION : shale, marl, chert, carbonate
Pdmcl Limestone, dolomite, shale
Pdmch Chert, chert breccia
Pdmsh Shale
Pdf FINLAYSON SANDSTONE : mature quartz arenite, minor conglomerate, shale

Undivided granitoid

Pre- and syn-tectonic granitoids — Late and post-tectonic granitoids

Agb Biotite adamellite, granite, minor granodiorite, medium to coarse-grained
Age Biotite adamellite, granite, minor granodiorite, fine to medium-grained
Agt Biotite adamellite and granite, porphyritic

Agm Mixed granite, abundant Age intruding Ags

Ags Gneissic biotite granodiorite and adamellite, recrystallized with granoblastic texture, shows nebulous banding and augen structure
Agt Hornblende granodiorite and tonalite, mylonitic fabric with minor recrystallisation

Amg Adamellite, granodiorite and tonalite gneiss, compositionally banded. Granoblastic quartz and feldspar, and aligned flakes of biotite
Amc Calc-silicate rock containing plagioclase-quartz-diopside-hornblende-K feldspar assemblage, usually compositionally banded

Az Undivided mafic, andesitic and dacitic lava, tuff, and minor fine-grained sediments
Azv Coarse-grained agglomeratic, blocks of mafic and andesitic lava in a fragmental matrix of similar composition
Azi Extrusive andesite, dacite and minor basalt, mostly vesicular, in part pyroclastic

Aiw Quartz-magnetite banded iron-formation, may contain mafic minerals
Aij Jaspilite, red and black banded
Aic Chert, banded, in part ferruginous

ARCHAEAN

Au Undivided metasedimentary rock
Aus Carbonaceous shale, mudstone, minor greywacke, often silicified to banded chert
Aug Greywacke and shale, shows graded bedding
Auc Conglomerate; chert and iron-formation clasts in a schistose greywacke matrix

Af Undivided felsic volcanic rock , generally deeply weathered
Afl Felsic lava, quartz-phyric, fine-grained to aphanitic, partly tuffaceous
Afv Medium-grained felsic tuff containing crystal and lithic fragments

Ad Undivided mafic intrusive rock
Add Dolerite, medium-grained
Adb Gabbro, coarse-grained
Ada Amphibolite, medium to coarse-grained, dynamically metamorphosed dolerite and gabbro with foliation and amphibole growth
Adm Layered gabbro and anorthosite containing magnetite layers

Ab Undivided mafic extrusive rock
Abb Basalt, fine-grained, locally vesicular, pillowed and/or porphyritic, mafic minerals generally pseudomorphed by actinolite
Aba Amphibolite, fine-grained, schistose, derived from mafic volcanics
Abk Komatiitic basalt, acicular and porphyritic texture, contains unaltered clinopyroxene, minor plagioclase
Abk Mafic tuff and agglomerate, containing crystal and lithic fragments
Aa Hornblende-plagioclase (clinopyroxene) amphibolite

Au Undivided ultramafic rock
Aud Serpentinite derived from dunite, cumulate texture preserved
Aup Peridotite, medium to coarse-grained, usually metamorphosed to serpentine-actinolite rock
Aux Pyroxenite, coarse-grained, usually metamorphosed to actinolite rock
Aur Actinolite-chlorite rock, generally schistose, metamorphosed mafic to ultramafic (including komatiitic) rocks
Aue Talc-carbonate (-chlorite-serpentine) altered ultramafic rock, schistose

GLENGARRY
SHEET SG 50 - 12

FIRST EDITION, 1981

WILUNA

AUSTRALIA 1:250000 GEOLOGICAL SERIES — **GEOLOGICAL SURVEY OF WESTERN AUSTRALIA** — **SHEET SG 51-9**

SYMBOLS

Geological boundary
- exposed
- concealed
- concealed, interpreted from aeromagnetic data

Structural symbols are labelled according to the sequence of local deformation events, where known
- Archaean deformation
  - D_1, D_2

Fault or shear zone
- exposed
- concealed
- concealed, interpreted from aeromagnetic data

Strongly foliated rock

Small-scale fold axis, showing trend and plunge
- unspecified
- S-vergence

Bedding, showing strike and dip
- inclined
- vertical
- horizontal
- trend of bedding

Way-up indicator
- pillow structure
- sedimentary structure

Metamorphic foliation, showing strike and dip
- inclined
- vertical

Mineral lineation, showing trend and plunge
- inclined
- horizontal
- crenulation, showing trend and plunge of axis, inclined

Intersection lineation, showing trend and plunge, inclined

Joint, fracture, or vein, showing strike and dip
- inclined
- vertical

Aeolian lineament
- prominent trend, unspecified
- fracture pattern in granitoid rock

Aeromagnetic lineament

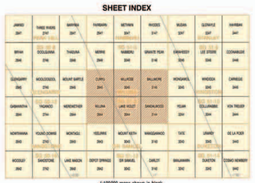
Formed road
Track
Railway, abandoned
Powerline
Landing ground
Homestead — Millrose
Building
Yard
Microwave repeater station
Horizontal control; minor
Breezeway
Sand dune

Watercourse with ephemeral pool, rockhole, soak, spring or waterhole
Waterhole
Soak
Spring
Bore
Well
Pipeline
Windpump
Tank
Abandoned
Position doubtful

Mineral field boundary
Mining centre — WILUNA
Mine (gold, unless otherwise indicated) — SC Bore West
Major opencut — Golden Age
Opencut — Happy Jack
Prospect
Treatment plant
Mining area
- mode ground
- tailings, mullock

Mineral exploration drillhole, showing subsurface data — 93 Argyle
Mineral occurrence
- Nickel — Ni
- Uranium — U

SHEET INDEX



1:100000 maps shown in black

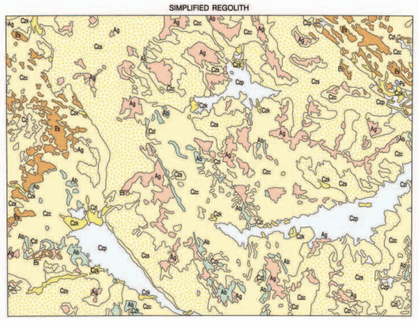
Published 1:100000 maps used in compilation

1:250000 maps shown in bright

See current GSWA map catalogue for full range of published products

The lines indicate magnetic declination, 1995. • means declination is east and correction must be added to compass bearing to give true bearing • means declination is west and correction must be subtracted from compass bearing to give true bearing. Annual change is 1' easterly

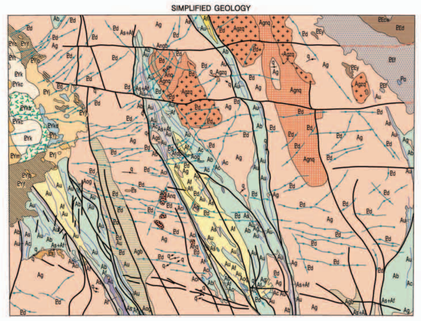
SIMPLIFIED REGOLITH



Cza Playa deposits
Czs Sandplain deposits
Czc Colluvium and sheetwash deposits
Czk Calcrete
Czl Surficial
Pz Permian sedimentary rock
Rx Proterozoic rock
Ag Archaean granitoid rock and associated elusium
Ab Archaean greenstone and associated elusium

SCALE 1:1000 000
0 10 20 30 40 50
Kilometres

SIMPLIFIED GEOLOGY



SCALE 1:1000 000
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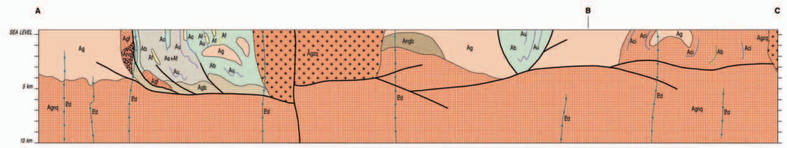
Kilometres

DIAGRAMMATIC SECTIONS

NATURAL SCALE



Compiled by T. R. Farrell 1997

Geology after GSWA and AGSO maps (see sheet index)

Edited by N. Tallow and G. Loon

Cartography by D. Lodbrook and B. Williams

Topography from the Department of Land Administration Sheet SG 51-9 with modifications from geological field survey

Published by the Geological Survey of Western Australia. Copies available from the Information Centre, Department of Minerals and Energy, 100 Plain Street, East Perth, WA, 6004. Phone (08) 9222 3459, Fax (08) 9222 3444

This map is also available in digital form

Printed by the Sands Print Group, Western Australia

The recommended reference for this map is:
FARRELL, T. R., 1999, Wiluna, W.A. Sheet SG 51-9 (2nd edition): Western Australia Geological Survey, 1:250000 Geological Series

REFERENCE

PHANEROZOIC — CAINOZOIC — QUATERNARY

Qc Qpc
Qc Alluvium — clay, silt, sand, and gravel; in channels and on floodplains
Qpc Clay and silt in claypans

Czb Czd Czp
Czb Ephemeral lake and dune deposits — clay, silt, and sand; in drainage basins adjacent to playa lakes
Czd Dune deposits — sand, silt, clay, gypsum, and carbonate; in low dunes adjacent to playa lakes
Czp Playa deposits — saline and gypsiferous evaporites, clay, and sand in playa lakes

Czs Czs
Czs Sheetwash deposits — clay, silt, and sand in extensive tonic; commonly ferruginous
Czs Sandplain deposits — unconsolidated sand and minor silt; includes stabilized dunes

Czc Czcq Czf Czg
Czc Colluvium — silt, sand, and rock debris as slope deposits and proximal sheetwash; includes ironstone fragments
Czcq Quartz vein rubble and debris
Czf Ferruginous rubble — degraded laterite duricrust, and ferruginous debris
Czg Sand over granitoid rock — quartzofeldspathic sand

Czk Czl Czu Czz
Czk Calcrete
Czl Laterite duricrust
Czu Silcrete caprock over ultramafic rock
Czz Silcrete

PALAEOZOIC — PERMIAN

Pe
Pe PATERSON FORMATION: sandstone, pebbly siltstone, and conglomerate

PROTEROZOIC — PALAEOPROTEROZOIC — EARAHEEDY BASIN

Ex
Ex Conglomerate, quartz-rich sandstone, arkosic sandstone, and microbial laminates; commonly silicified and brecciated

Earaheedy Group

ECcw
ECcw CHALLI FORMATION: Wandiwarra Member: siltstone and shale, and subordinate sandstone

ECd
ECd WINDIDDA FORMATION: limestone and shale

EBf
EBf FRERE FORMATION: granular iron formation, ferruginous siltstone, and shale; minor banded iron-formation and chert

EBy
EBy YELMA FORMATION: sandstone, shale, and minor conglomerate

YERRIDA BASIN

Yerrida Group — Mibbonjoon Subgroup

EYk
EYk KILLARA FORMATION: undivided mafic intrusive and extrusive rocks (simplified geology only)

EYkc
EYkc Borlie Member: chertified microbial laminites with borlie and anhydrite nodules

EYkd
EYkd Medium- to coarse-grained dolerite dykes and sills

EYkp
EYkp Aphyric tholeiitic basalt

Wyloo Subgroup

EYj
EYj JUDERINA FORMATION: quartz sandstone; local siltstone, chert breccia, and conglomerate

EYjb
EYjb Bubble Well Member: stromatolitic chert and chert breccia; minor dolomite

EYy
EYy Finlayson Member: quartz arenite and subordinate siltstone; planar-bedded or cross-stratified; commonly ripple-marked

Bx
Bx Mafic dyke

q
q Quartz vein

Aga
Aga Granitoid rock, undivided

Agp
Agp Fine-grained granitoid rock

Agh
Agh Foliated granitoid rock with interleaved mafic rock

Agd
Agd Diorite and quartz diorite

Agdq
Agdq Quartz diorite and quartz monzodiorite (subsurface only)

Agf
Agf Foliated granitoid rock

Agg
Agg Granodiorite

Agm
Agm Biotite monzogranite

Agmh
Agmh Hornblende monzogranite (subsurface only)

Agmp
Agmp Porphyritic biotite monzogranite

Agng
Agng Granitoid rock and quartzofeldspathic gneiss; minor calc-silicate gneiss and mafic gneiss

Agns
Agns Hornblende quartz monzonite; minor quartz diorite

Angb
Angb Interlayered quartzofeldspathic gneiss, monzonite, and metamorphosed mafic rock

Anq
Anq Quartzofeldspathic gneiss, commonly with diffuse layering

Aqf
Aqf Quartz–feldspar schist

As Asc Asd Ash Ass
As Metamorphosed sedimentary rock, undivided; includes minor felsic volcaniclastic rock
Asc Polymictic conglomerate; metamorphosed
Asd Dolomite; metamorphosed
Ash Shale, and minor siltstone and sandstone; metamorphosed
Ass Sandstone and minor siltstone; metamorphosed

Ac Acq
Ac Chert and banded chert; metamorphosed
Acq Banded iron-formation; metamorphosed

Af Afdp Afi Afp Afs Aft
Af Metamorphosed felsic rock, undivided
Afdp Porphyritic dacite; metamorphosed
Afi Intermediate volcanic rock; metamorphosed
Afp Porphyritic felsic rock; metamorphosed
Afs Felsic schist
Aft Felsic tuff; metamorphosed

Amg Amgt Amgb
Amg Metagabbro
Amgt Strongly foliated gabbro; metamorphosed
Amgb Olivine gabbro; metamorphosed

Ab Abo Abt Abg Abm Abs Aby
Ab Metamorphosed fine- to medium-grained mafic rock, undivided; includes some metagabbro
Abo Amphibolite; generally fine- to medium-grained
Abt Strongly foliated metamorphosed mafic rock
Abg Strongly foliated metamorphosed mafic rock interleaved with minor foliated granitoid rock
Abs Porphyritic basaltic andesite; metamorphosed (subsurface only)
Abm High-Mg basalt; commonly with pyroxene-spinifex and varioltic textures; metamorphosed
Abs Mafic schist; chlorite-rich schist, probably after high-Mg basalt
Aby Amygdaloidal basalt; metamorphosed

Au Aup Aua Aut Aue
Au Metamorphosed ultramafic rock, undivided
Aup Peridotite; metamorphosed
Aua Serpentinised ultramafic rock
Aut Talc–chlorite(–carbonate) schist
Aue Pyroxenite; metamorphosed

ARCHAEAN — YILGARN CRATON — NORTHERN YILGARN

GOVERNMENT OF WESTERN AUSTRALIA
HON. NORMAN MOORE, M.L.C.
MINISTER FOR MINES

DEPARTMENT OF MINERALS AND ENERGY
L. C. RAWCHEV, DIRECTOR GENERAL

NGMA
PRODUCT OF THE NATIONAL GEOSCIENCE MAPPING ACCORD

AUSTRALIAN GEOLOGICAL SURVEY ORGANISATION

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA
DAVID BLIGHT, DIRECTOR

SCALE 1:250 000

5000 0 5 10 15 20 25 30
Metres Kilometres

TRANSVERSE MERCATOR PROJECTION
HORIZONTAL DATUM: AUSTRALIAN GEODETIC DATUM 1984
VERTICAL DATUM: AUSTRALIAN HEIGHT DATUM
Grid lines indicate 20 000 metre interval of the Australian Map Grid Zone 51

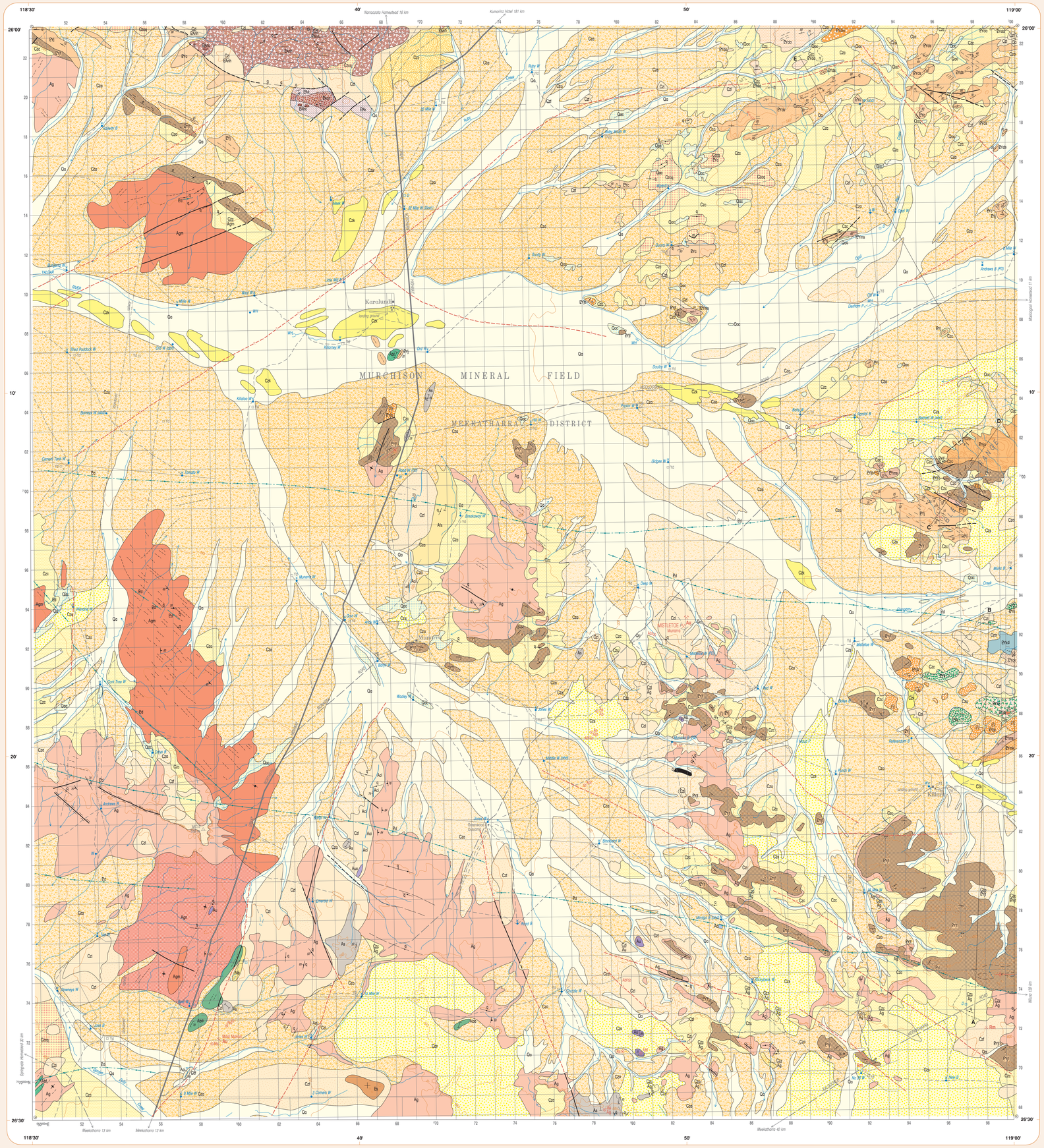
WILUNA

SHEET SG 51-9

SECOND EDITION 1999

GLENGARRY

AUSTRALIA 1:100 000 GEOLOGICAL SERIES | **GEOLOGICAL SURVEY OF WESTERN AUSTRALIA** | **SHEET 2645**



PHANEROZOIC — CAINOZOIC — QUATERNARY

Qa Alluvial deposits—sand and silt in channels and floodplains
Qac Clay and silt in claypans

Czs Sheetwash deposits—ferruginous clay, silt, and sand as extensive fans
Czc Colluvium—gravel, sand, and silt as scree and sheetwash
Czcq Quartz vein rubble and debris
Czf Ferruginized rubble and colluvium—dominantly ferruginized pisolites and nodules, ferruginized rock, and ironstone rubble; degraded lateritic duricrust
Czk Colcrete
Czl Lateritic deposits—nodular and pisolitic laterite, and associated debris
Cza Sandplain deposits—unconsolidated sand; minor silt and clay; includes low, vegetated dunes
Czz Silcrete

Quartz veins and pods

Dolerite dyke, dashed where interpreted from aeromagnetic data

Gossan, gossanous zone

Conglomerate, sandstone, and siltstone

PROTEROZOIC — Bryah Group — BRYAH BASIN

EAn **NARRACOOTA FORMATION:** metabasaltic lava and mafic schist
EAnc Jasperoidal chert
EAnh Metabasaltic hyaloclastite
EAnt Metabasaltic hyaloclastite, metamicrogabbro, mafic pyroclastic rock, and autoclastic breccia

EAk **KARALUNDI FORMATION:** quartz-lithic wacke and silicified arenite; local carbonate rock; metamorphosed

PROTEROZOIC — Yerrida Group — YERRIDA BASIN

Macalopgori Subgroup

PYm **MARALDOU FORMATION:** undivided sedimentary rock (not on map)
PYms Thin-bedded siltstone
PYmk Fine-grained limestone; local intercalations of thin amygdaloidal basalt

PYk **KILLARA FORMATION:** undivided mafic intrusive and extrusive rocks, and intercalated thin chertified volcaniclastic rock
PYkd Medium- to coarse-grained dolleritic dykes and sills
PYkv Aphyric tholeiitic lava

Windplain Subgroup

PYd **DOOLGUNNA FORMATION:** arkosic wacke and quartz sandstone; minor pebble conglomerate (section only)
PYda Arkosic wacke with subordinate kaolinitic quartz sandstone and siltstone; minor conglomerate
PYdm Diamictite: polymictic conglomerate and breccia in arkosic matrix
PYds Laminated quartz sandstone and siltstone; minor pebble conglomerate

PYc **JOHNSON CAIRN FORMATION:** argillaceous siltstone and thin-bedded dolomite; minor sandstone
PYck Dolomite, shale and marl

PYj **JUDERINA FORMATION:** quartz sandstone; minor siltstone, chert breccia, and pebble conglomerate
PYjb **Bubble Member:** stromatolitic chert and chert breccia
PYjo Thick-bedded sandstone with widespread mudstone intraclasts; minor intercalated shale
PYjr **Finlayson Member:** quartz arenite and subordinate siltstone; planar bedded or cross-stratified, commonly ripple-marked

ARCHAEAN — YILGARN CRATON

Ag Undivided granitoid rock; locally equivalent to Agm
Agm Monzogranite; K-feldspar megacrysts abundant locally
Agn Gneissic granitoid rock; with local mafic enclaves

As Metasedimentary rock
Ac Chert and banded chert
Aci Banded iron-formation
Afs Felsic schist
Afp Felsic porphyry; metamorphosed

Abo Amphibolite
Abf Mafic schist
Au Ultramafic rock
Aux Metapyroxenite

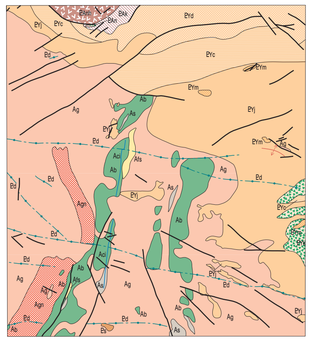
Geological boundary — exposed / concealed
Fault or shear showing dip of fault plane — exposed / concealed / interpreted from aeromagnetic data / mylonite zone / strongly foliated rock
Fold, showing trend — anticline / syncline
Minor fold, showing plunge — anticline
Bedding, showing strike and dip — horizontal / inclined / vertical / overturned / interpreted from aerial photographs; dip 15°-45°
Direction of movement of sediment-bearing current, from cross-bedding / from asymmetrical ripple marks
Metamorphic foliation, showing strike and dip — inclined / vertical
Cleavage, showing strike and dip — inclined / vertical
Crenulation cleavage, showing strike and dip — vertical
Fracture or joint, showing strike and dip — inclined / vertical
Stromatolite locality
Aeriphoto lineaments — structural trend / foliation or bedding trend / foliation trend in granitoid rock

Highway with national route marker
Formed road
Track
Fence, generally with track
Homestead — Killara
Building
Yard
Microwave repeater station
Horizontal control, major
Breakaway
Sand dune
Contour line, 20 metre interval

Watercourse, ephemeral — Wirr
Waterhole
Pool
Bore
Well
Windpump
Dam
Tank
Abandoned — (abd)
Position doubtful — (PD)

Mining centre — MISTLETOE
Mine (gold, unless otherwise indicated) — Munarra
Opencut
Prospect — Mold Marion
Mineral exploration drillhole or costean, showing subsurface data — As
Mineral occurrence
Gold — Au
Road materials — Rm

SIMPLIFIED GEOLOGY



Ek Proterozoic sedimentary rocks; unassigned

Bryah Group: Narracoota Formation; Metabasaltic hyaloclastite; Karalundi Formation — BRYAH BASIN

Yerrida Group: Maraldou Formation; Killara Formation; Doolgunna Formation; Johnson Cairn Formation; Juderina Formation — YERRIDA BASIN

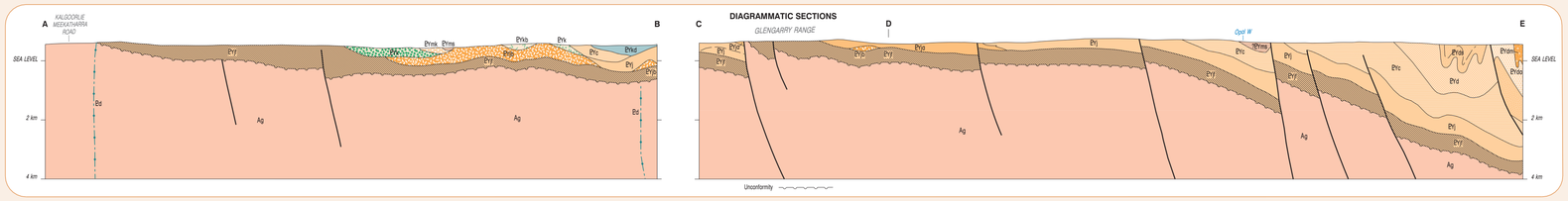
Ag Granitoid rock
Agn Gneissic granitoid rock

As Metasedimentary rock
Aci Banded iron-formation
Afs Felsic schist
Ab Mafic and ultramafic schist

— YILGARN CRATON

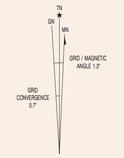
SCALE 1:100 000
0 5 10 15 20 Kilometres

DIAGRAMMATIC SECTIONS



SHEET INDEX

1:100 000 maps shown in black
1:250 000 maps shown in brown



True north, grid north and magnetic north are shown diagrammatically for the centre of the map. Magnetic north is correct for 1990 and moves easterly by about 0.1° in 6 years.

DEPARTMENT OF MINERALS AND ENERGY
L. C. RAWLINSON, DIRECTOR GENERAL

GOVERNMENT OF WESTERN AUSTRALIA
HON. NORMAN MOORE, M.L.C.
MINISTER FOR MINES

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA
DAVID BLIGHT, DIRECTOR

SCALE 1:100 000
1000 0 1 2 3 4 5 6 7 8 9 10
Metres — Kilometres

UNIVERSAL TRANSVERSE MERCATOR PROJECTION
HORIZONTAL DATUM: GEOCENTRIC DATUM OF AUSTRALIA 1994
VERTICAL DATUM: AUSTRALIAN HEIGHT DATUM
Grid lines indicate 1000 metre interval of the Map Grid Australia Zone 50

GDA
The Map Grid Australia (MGA) is based on the Geocentric Datum of Australia 1994 (GDA94)
GDA94 positions are compatible within one metre of the datum WGS84 positions

⊙ Reference points to align maps based on the previous datum, AGD84, have been placed near the map corners

Geology by F. Pirajno, N. G. Adamides, and D. D. Ferdinando 1995

Edited by D. Ferdinando, S. Willis, and G. Loan

Cartography by D. Ladbrook

Topography from the Department of Land Administration Sheet SG 50-12, 2645, with modifications from geological field survey

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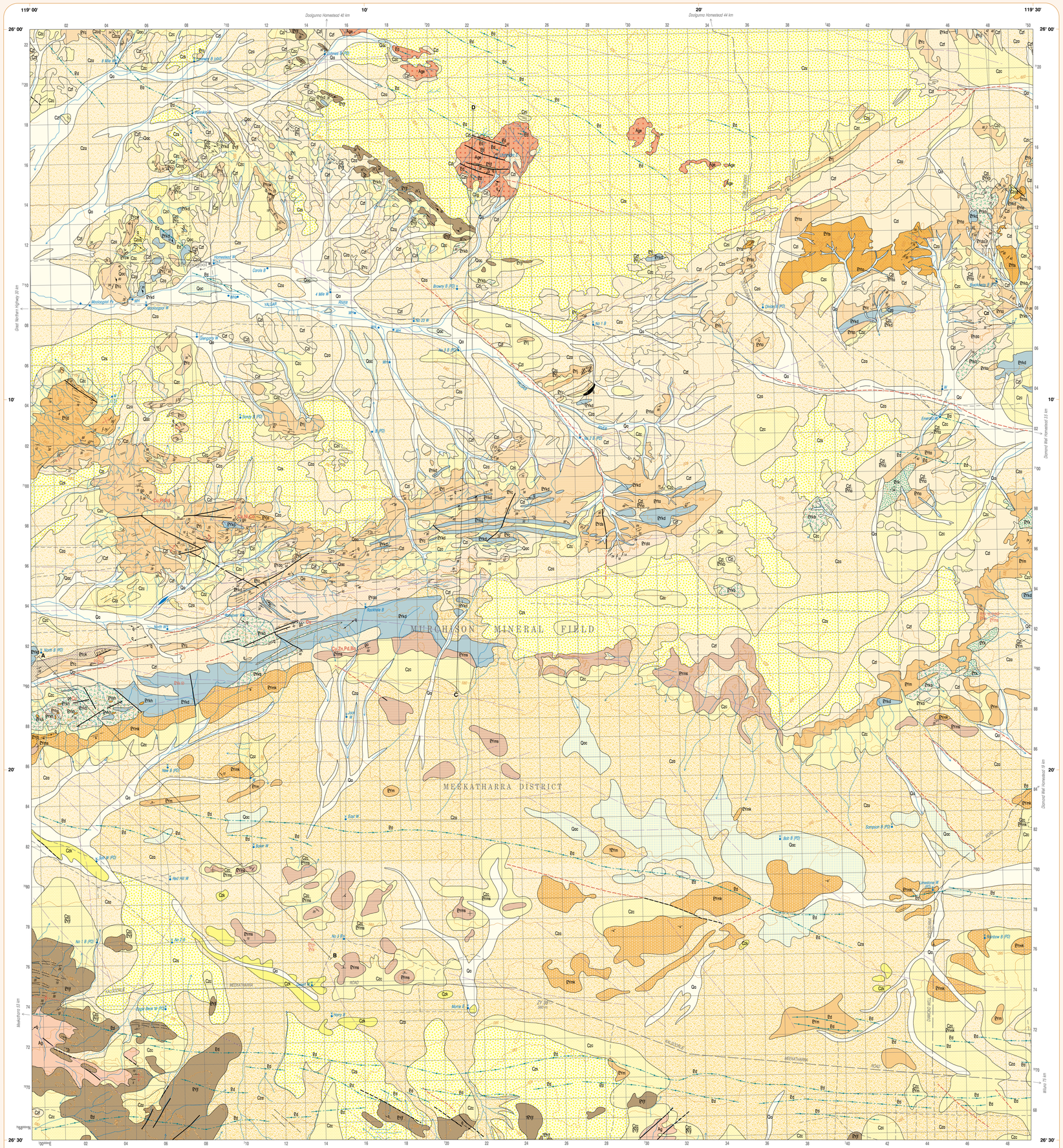
The recommended reference for this map is: PIRAJNO, F., ADAMIDES, N. G., and FERDINANDO, D. D., 1997 Glengarry, W.A. Sheet 2645. Western Australia Geological Survey, 1:100 000 Geological Series

GLENGARRY

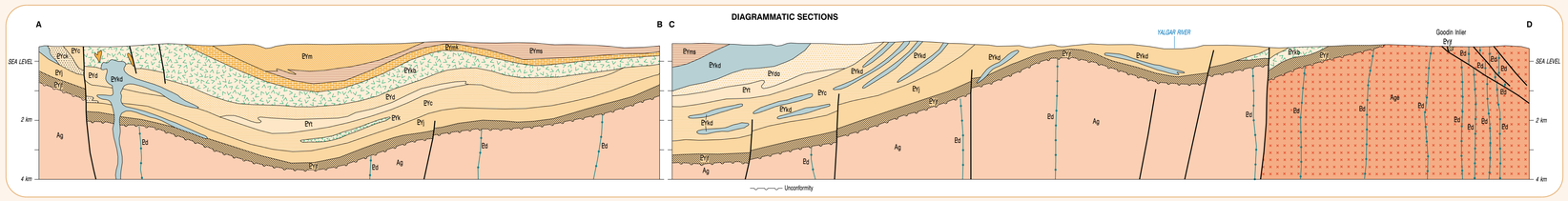
SHEET 2645 **FIRST EDITION 1997**

MOOLOOGOOL

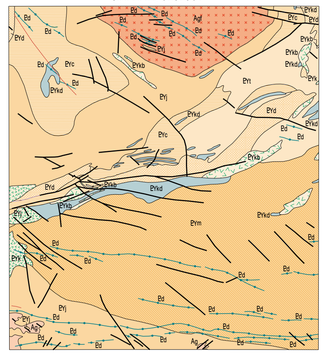
AUSTRALIA 1:100 000 GEOLOGICAL SERIES — **GEOLOGICAL SURVEY OF WESTERN AUSTRALIA** — **SHEET 2745**



DIAGRAMMATIC SECTIONS



SIMPLIFIED GEOLOGY



Yerrida Group: Dolerite dyke; Marraloou Formation; Killara Formation; Basalt; Dolerite; Doolgunna Formation; Thaduna Formation; Johnson Cairn Formation; Juderina Formation — YERRIDA BASIN

Granitoid rock — GOODIN INLIER, YILGARN CRATON

Granitoid rock

SCALE 1:500 000

0 5 10 15 20 Kilometres

SHEET INDEX

ERNMOUNT 2347	MARQUIS 2447	WILSON 2547	JAMIRO 2647	THREE RIVERS 2747	MARYMAN 2847
ROBINSON RANGE	SG 50-3			PEAK HILL	
GOULD 2346	MCDIARMID 2446	PADBURY 2546	BRYAH 2646	DOOLGUNNA 2746	THADUNA 2846
BELELE	SG 50-11			QUEANBEYAN	SG 50-12
WILSON 2345	KOOMARRA 2445	TERACO 2545	GLENGARRY 2645	MOOLOOGOOL 2745	MOUNT BARTLE 2845
KALU 2344	MACCOONGA 2444	MEEKATHARRA 2544	GABANINTHA 2644	TAGANGO 2744	MEREWETHER 2844

1:100 000 maps shown in block

1:250 000 maps shown in brown

TN GN MN

GRID/MAGNETIC ANGLE 1.9°

GRID CONVERGENCE 1.0°

True north, grid north and magnetic north are shown diagrammatically for the centre of the map. Magnetic north is correct for 1997 and moves easterly by about 0.1° in 2 years

SCALE 1:100 000

1000 0 1 2 3 4 5 6 7 8 9 10 Metres — Kilometres

TRANSVERSE MERCATOR PROJECTION

Grid lines indicate 1000 metre interval of the Australian Map Grid Zone 50

DEPARTMENT OF MINERALS AND ENERGY
L. C. RAWLINSON, ACTING DIRECTOR GENERAL

GOVERNMENT OF WESTERN AUSTRALIA
HON. NORMAN MOORE, M.L.C.
MINISTER FOR MINES

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA
PETRO GUL, DIRECTOR

Geology by F. Pirajno, N. G. Adamides, and S. A. Occhipinti 1995

Edited by D. Ferdinando and G. Loon

Cartography by P. Taylor

Topography from the Department of Land Administration Sheet SG 50-12, 2745, with modifications from geological field survey

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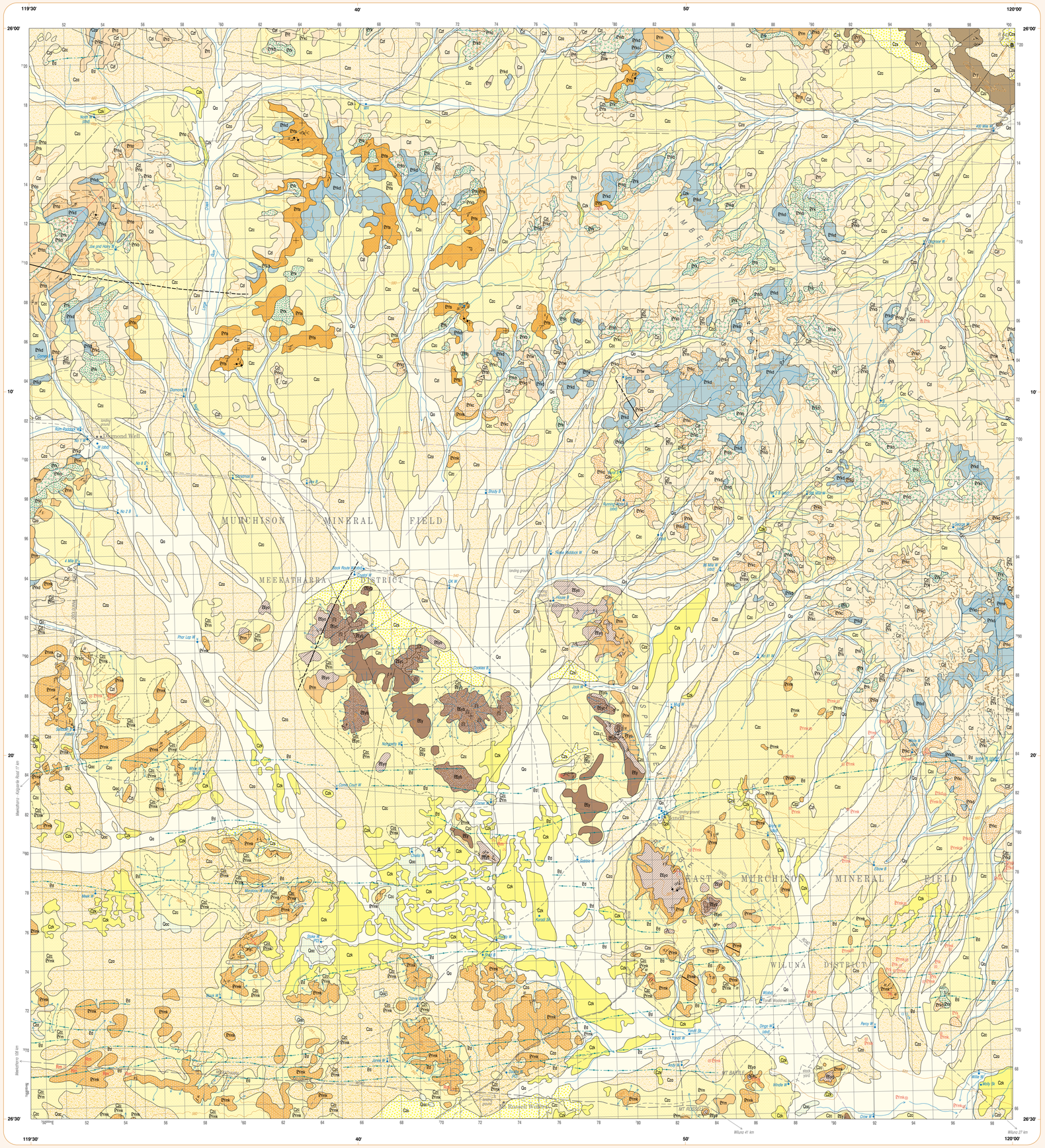
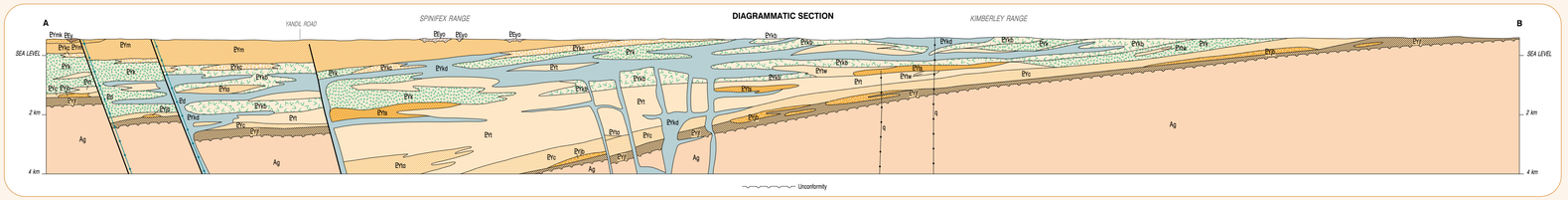
MOOLOOGOOL

SHEET 2745 FIRST EDITION 1997

MOUNT BARTLE

AUSTRALIA 1 : 100 000 GEOLOGICAL SERIES | **GEOLOGICAL SURVEY OF WESTERN AUSTRALIA** | **SHEET 2845**





PHANEROZOIC — CAINOZOIC — QUATERNARY

- Qa — Alluvium—sand and silt in channels and floodplains
- Qac — Clay and silt in claypans

- Czo — Sheetwash deposits—ferruginous clay, silt, and sand as extensive fans
- Czc — Colluvium—gravel, sand, and silt as scree and sheetwash
- Czf — Ferruginized rubble and colluvium—dominantly ferruginized pisolites and nodules, ferruginized rock and ironstone rubble; degraded lateritic duricrust
- Czk — Calcrete
- Czl — Lateritic deposits—nodular and pisolitic laterite, and associated debris
- Czli — Ironstone duricrust; massive and rubbly
- Czs — Sandplain deposits—unconsolidated sand; minor silt and clay; includes low, vegetated dunes
- Cz — Silcrete

- q — Quartz veins
- Bd — Dolerite dykes; interpreted from aeromagnetic data

PROTEROZOIC — EARAHEEDY BASIN — Earaheedy Group

- Bby — **YELMA FORMATION:** laminated dolomitic siltstone and shale, locally graded; minor dolomite lenses, stromatolites, and chert bands
- Bbyc — Chert and chert breccia after carbonate, stromatolites, and argillite
- Bbyo — Stromatolitic dolomite; minor argillaceous and chert bands
- Bbya — Cross-stratified quartz sandstone with basal chert and quartz conglomerate; minor argillite and dolomite

PROTEROZOIC — YERRIDA BASIN — Yerrida Group — Manganese Subgroup

- Bym — **MARALOOU FORMATION:** argillaceous dolomitic limestone and interbedded siltstone; minor thin bedded limestone and dolomite
- Bymx — Dolomitic and calcareous siltstone with layers of disseminated iron-rich concretions; minor quartz arenite and quartz wacke
- Bymc — **Bortle Member:** chert, chert breccia, laminated chert, and chertified sedimentary rock; locally with pseudomorphs of anhydrite crystals and nodules; minor basaltic lava
- Bym — **KILLARA FORMATION:** undivided mafic rocks (cowcul and interbedded with THADUNA and DOOLGUNNA FORMATIONS)
- Bmd — Dolerite and gabbro, mainly in sills; minor disseminated sulfides (hypabyssal equivalent of Bym)
- Bmm — Basaltic lava; locally amygdaloidal; minor nontronite layers

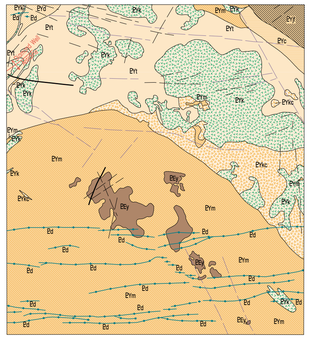
PROTEROZOIC — YERRIDA BASIN — Yerrida Group — Woolgidee Subgroup

- Bth — **THADUNA FORMATION:** undifferentiated siliciclastic sedimentary rocks and chert (cowcul and interbedded with KILLARA and DOOLGUNNA FORMATIONS)
- Bthw — Litharenite and lithic wacke; locally mica-bearing and feldspathic; minor conglomerate
- Bths — Quartzose to feldspathic litharenite and lithic wacke, with shale and siltstone; minor conglomerate
- Bths — Litharenite, ferruginous quartz arenite, quartz wacke, and shale
- Bmd — **DOOLGUNNA FORMATION:** arkosic sandstone; minor subarkosic to quartzose sandstone, granule conglomerate, and shale in upward thinning turbidite cycles (cowcul and interbedded with KILLARA and THADUNA FORMATIONS)
- Bmc — **JOHNSON CAIRN FORMATION:** shale and siltstone, partly carbonaceous and dolomitic; minor quartz arenite, wacke, dolomite lenses, and disseminated lenses of iron-rich concretions
- Bmj — **JUDERINA FORMATION:** undivided siliciclastic and carbonate sedimentary rock (not on map)
- Bmjb — **Bubble Member:** laminated stromatolitic chert, stromatolitic carbonate beds, and dolostone (section only)
- Bmjf — **Finlayson Member:** quartz arenite; planar bedded on cross-stratified minor pebble conglomerate and intercalated siltstone

ARCHAEAN — YILGARN CRATON

- Ag — Undivided granitoid rock and greenstone (section only)

SIMPLIFIED GEOLOGY



Bd — Dolerite dyke

Earaheedy Group — EARAHEEDY BASIN
- Bby — Yelma Formation

Yerrida Group — YERRIDA BASIN
- Bym — Maroloou Formation
- Bymc — Bortle Member
- Bmm — Killara Formation
- Bth — Thaduna Formation
- Bmd — Doolgunna Formation
- Bmc — Johnson Cairn Formation
- Bmj — Juderina Formation
- Bmjf — Finlayson Member

SCALE 1:500000

0 5 10 15 20 Kilometres

DEPARTMENT OF MINERALS AND ENERGY
K.R. PERRY, DIRECTOR GENERAL

GOVERNMENT OF WESTERN AUSTRALIA
HON. KEVIN MINSON, M.L.A.
MINISTER FOR MINES

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA
PIETRO GUI, DIRECTOR

SCALE 1:100 000

1000 0 1 2 3 4 5 6 7 8 9 10 Metres Kilometres

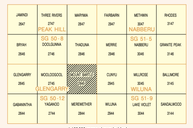
TRANSVERSE MERCATOR PROJECTION
Grid lines indicate 1000 metre interval of the Australian Map Grid Zone 50

Geological boundary — exposed; concealed
Fault — exposed, partly based on aeromagnetic data; concealed; concealed, position uncertain
Fold, showing trend and plunge direction — anticline, concealed; syncline, concealed; minor fold
Bedding, showing strike and dip — inclined; horizontal; strike and dip estimated from aerial photography; 0 — 15°; trend
Direction of movement of sediment-bearing currents — sense known: x—cross-stratification; sense not known: f—flute, s—scour
Fracture or joint, showing strike and dip — vertical
Stromatolite locality
Airphoto lineament, unspecified
Aeromagnetic lineament

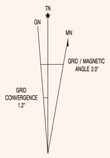
Formed road
Track
Fence, generally with track
Homestead — Permo
Building
Microwave repeater station
Horizontal control, minor
Breakaway
Contour line, 20 metre interval — 120
Watercourse, ephemeral
Waterhole — WH
Rockhole — RH
Spring — S
Soak — Sk
Windpump
Tank — T
Bore — B
Well — W
Abandoned — (dbd)
Position doubtful — (PD)

Mineral field boundary
Quarry
Mineral exploration drill hole, showing subsurface data — Bym
Mineral occurrence — Building stone — Bs; Road materials — Rm

SHEET INDEX



1:100000 maps shown in black
1:250000 maps shown in brown



True north, grid north and magnetic north are shown diagrammatically for the centre of the map. Magnetic north is correct for 1996 and moves westerly by about 0.1° in 6 years.

Geology by P.R. Dawes and G. Le Blanc Smith 1994
Revised by P.R. Dawes, S.A. Occhipinti, and F. Pirajno 1996

Edited by D. Ferdinando and G. Loan

Cartography by C. Bartlett, K. Greenberg, and P. Taylor

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MOUNT BARTLE

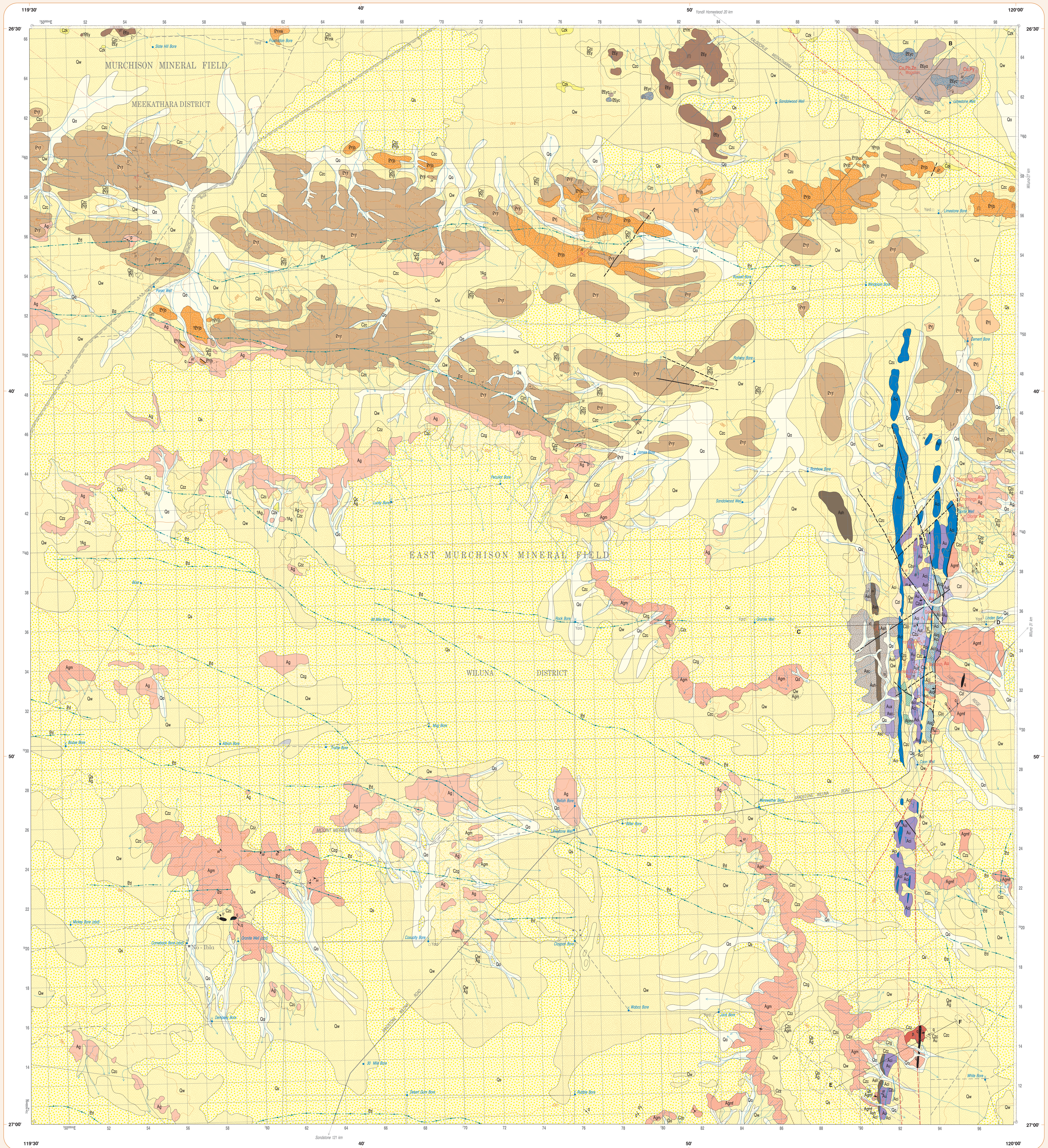
SHEET 2845 FIRST EDITION 1996

MEREWETHER

AUSTRALIA 1 : 100 000 GEOLOGICAL SERIES

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

SHEET 2844



PHANEROZOIC — CAINOZOIC — QUATERNARY

- Qa — Alluvial deposits — sand and silt in channels and on floodplains
- Qc — Colluvial deposits — unconsolidated rock fragments on scree slopes
- Qs — Sandplain — unconsolidated sand as sheets and rare dunes
- Qw — Sheetwash — clay, silt, sand, and gravel in distal outwash deposits

CAINOZOIC

- Czc — Colluvium — gravel, sand, and silt as scree and sheetwash
- Czg — Sand over granitoid rock — predominantly quartzofeldspathic
- Czk — Calcrete
- Czl — Lateritic deposits — nodular and pisolitic ferruginous duricrust, and associated debris
- Czu — Silica caprock over ultramafic rock
- Czz — Siliceous duricrust

- q — Quartz veins and pods
- p — Pegmatite veins and pods

PROTEROZOIC — PALAEOPROTEROZOIC

- Ed — Dolerite dyke; interpreted from aeromagnetic data where dashed (YILGARN CRATON)

Earaheedy Group — Tooloo Subgroup (EARAHEEDY BASIN)

- EEy — **YELMA FORMATION:** dolomitic siltstone and shale in graded laminites; minor dolomite lenses
- EEyc — Stromatolitic chert and chert breccia
- EEya — Thin-bedded, fine- to medium-grained sandstone, siltstone, and shale; locally feldspathic

Yerrida Group (YERRIDA BASIN)

Mooloogool Subgroup

- EYmk — **MARALOOU FORMATION** Calcareous siltstone with minor quartz arenite and quartz wacke

Windplain Subgroup

- EYj — **JUDERINA FORMATION:** quartz sandstone; minor siltstone, chert breccia, and pebble conglomerate
- EYjb — **Bubble Well Member:** stromatolitic chert and chert breccia
- EYjf — **Finlayson Member:** quartz arenite and minor siltstone; planar bedded or cross-stratified; commonly ripple marked

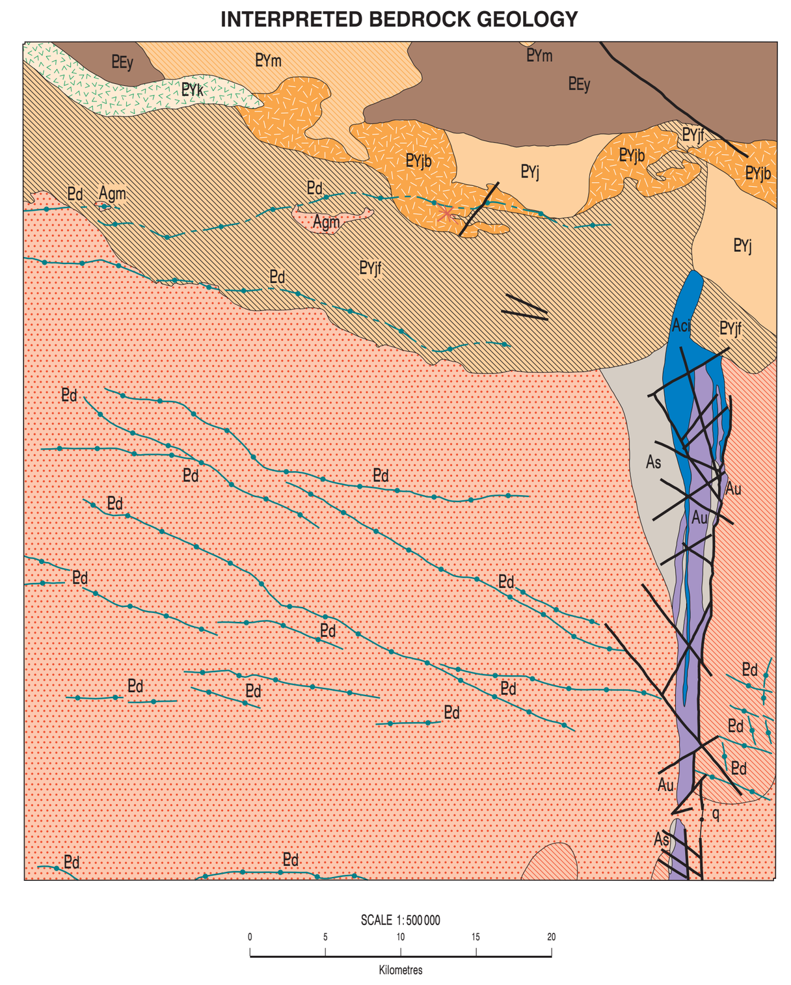
ARCHAEAN (YILGARN CRATON)

- Ag — Granitoid rock, undivided
- Agm — Biotite monzogranite; local epidote alteration
- Agmf — Strongly foliated porphyritic biotite monzogranite; locally interleaved with mafic schist
- Alql — Quartz–chlorite schist; includes mafic rock fragments
- Asc — Pebble conglomerate; contains chert and banded iron-formation clasts; metamorphosed
- Ash — Shale and siltstone; metamorphosed to quartz-biotite-garnet schist
- Aci — Banded iron-formation and chert; metamorphosed
- Abms — High-Mg basalt; metamorphosed to tremolite-actinolite-plagioclase schist
- Au — Ultramafic rock, undivided; local spinifex texture; includes some mafic rock; metamorphosed
- Aut — Talc–actinolite-chlorite(–tremolite) schist; typically deeply weathered; local spinifex texture
- Aux — Feldspathic pyroxenite; metamorphosed

Map symbols

- Geological boundary: exposed; concealed; concealed, interpreted from aeromagnetic data
- Fault or shear: exposed; concealed; concealed, interpreted from aeromagnetic data
- Strongly foliated rock
- Fold, showing axial trace: syncline; exposed, concealed
- Small-scale fold axis, showing trend and plunge: anticline (20); syncline (25); Z-vergence (28)
- Bedding, showing strike and dip: inclined (74); vertical
- Foliation, showing strike and dip: inclined (4); vertical
- Cleavage, showing strike and dip: inclined (84)
- Lineation, showing trend and plunge: axis of crenulation, inclined (68)
- Joint, showing strike and dip: inclined (68)
- Airphoto or satellite lineament: fracture pattern in granitoid rock
- Aeromagnetic lineament
- Stromatolite fossil locality
- Formed road
- Track
- Fence, generally with track
- Abandoned railway
- Homestead — No - Ibla
- Building
- Yard — Yard
- Breakaway
- Sand dune
- Contour line, 20 metre interval — 560
- Watercourse
- Bore, well — Bore, Well
- Windpump
- Abandoned — (abd)
- Mineral field boundary
- Mine — Joyners Find
- Prospect
- Mineral exploration drillhole, showing subsurface data — Au
- Mineral occurrence
- Copper — Cu
- Gold — Au
- Lead — Pb
- Pyrite — Py
- Zinc — Zn

INTERPRETED BEDROCK GEOLOGY



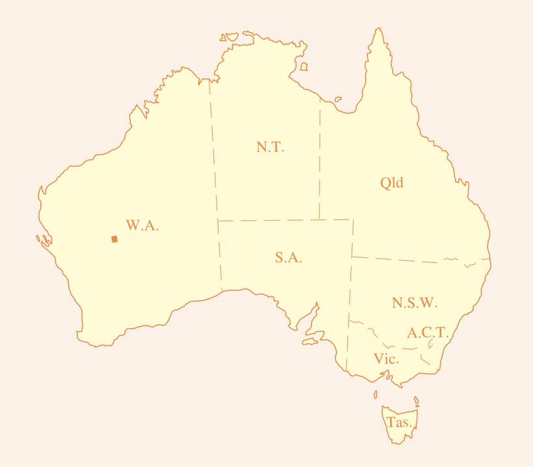
- q — Quartz vein
- Ed — Mafic dyke; dashed beneath Proterozoic rock (YILGARN CRATON)
- Earaheedy Group: EEy — Yelma Formation (EARAHEEDY BASIN)
- Yerrida Group (YERRIDA BASIN): EYm — Maraloou Formation; EYk — Killara Formation; EYj — Juderina Formation; EYjb — Bubble Well Member; EYjf — Finlayson Member
- YILGARN CRATON: Agm — Monzogranite; Agmf — Strongly foliated monzogranite; As — Metasedimentary rock; Aci — Banded iron-formation and chert; Au — Metamorphosed ultramafic and mafic rocks

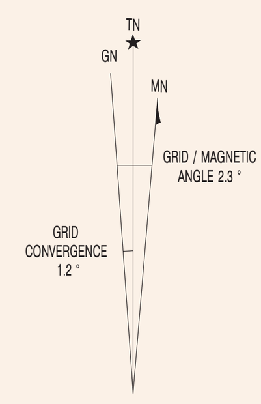
SHEET INDEX

GLENGARRY 2645	MOOLOOGOOL 2745 GLENGARRY	MOUNT BARTLE 2845	CUNYU 2945	MILLROSE 3045 WILUNA	BALLIMORE 3145
GABANINTHA 2644	SG 50-12 YAGANOO 2744	MEREWETHER 2844	WILUNA 2944	SG 51-9 LAKE VIOLET 3044	SANDALWOOD 3144
NOWTHANNA 2643	YOUNO DOWNS 2743 SANDSTONE	MONTAGU 2843	YEELIRRIE 2943	MOUNT KEITH 3043 SIR SAMUEL	WANGGANNOO 3143
WOODLEY 2642	SG 50-16 SANDSTONE 2742	LAKE MASON 2842	DEPOT SPRINGS 2942	SG 51-13 SIR SAMUEL 3042	DARLOT 3142

1:100 000 maps shown in black

1:250 000 maps shown in brown





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L. C. RANFORD, DIRECTOR GENERAL

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HON. NORMAN MOORE, M.L.C.
MINISTER FOR MINES

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA
DAVID BLIGHT, DIRECTOR

SCALE 1:100 000

1000 0 1 2 3 4 5 6 7 8 9 10 — Metres / Kilometres

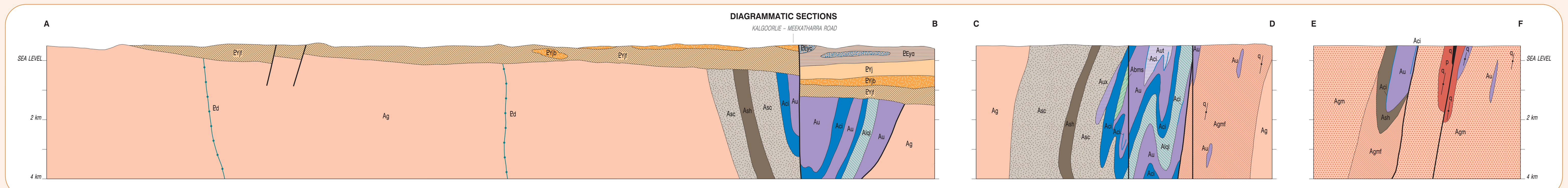
UNIVERSAL TRANSVERSE MERCATOR PROJECTION
HORIZONTAL DATUM: GEOCENTRIC DATUM OF AUSTRALIA 1994
VERTICAL DATUM: AUSTRALIAN HEIGHT DATUM

Grid lines indicate 1000 metre interval of the Map Grid Australia Zone 50

The Map Grid Australia (MGA) is based on the Geocentric Datum of Australia 1994 (GDA94)
GDA94 positions are compatible within one metre of the datum WGS84 positions

Reference points to align maps based on the previous datum, AGD84, have been placed near the map corners

DIAGRAMMATIC SECTIONS



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Plotted by Geological Survey of Western Australia

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MEREWETHER

SHEET 2844 FIRST EDITION 2000

WILUNA

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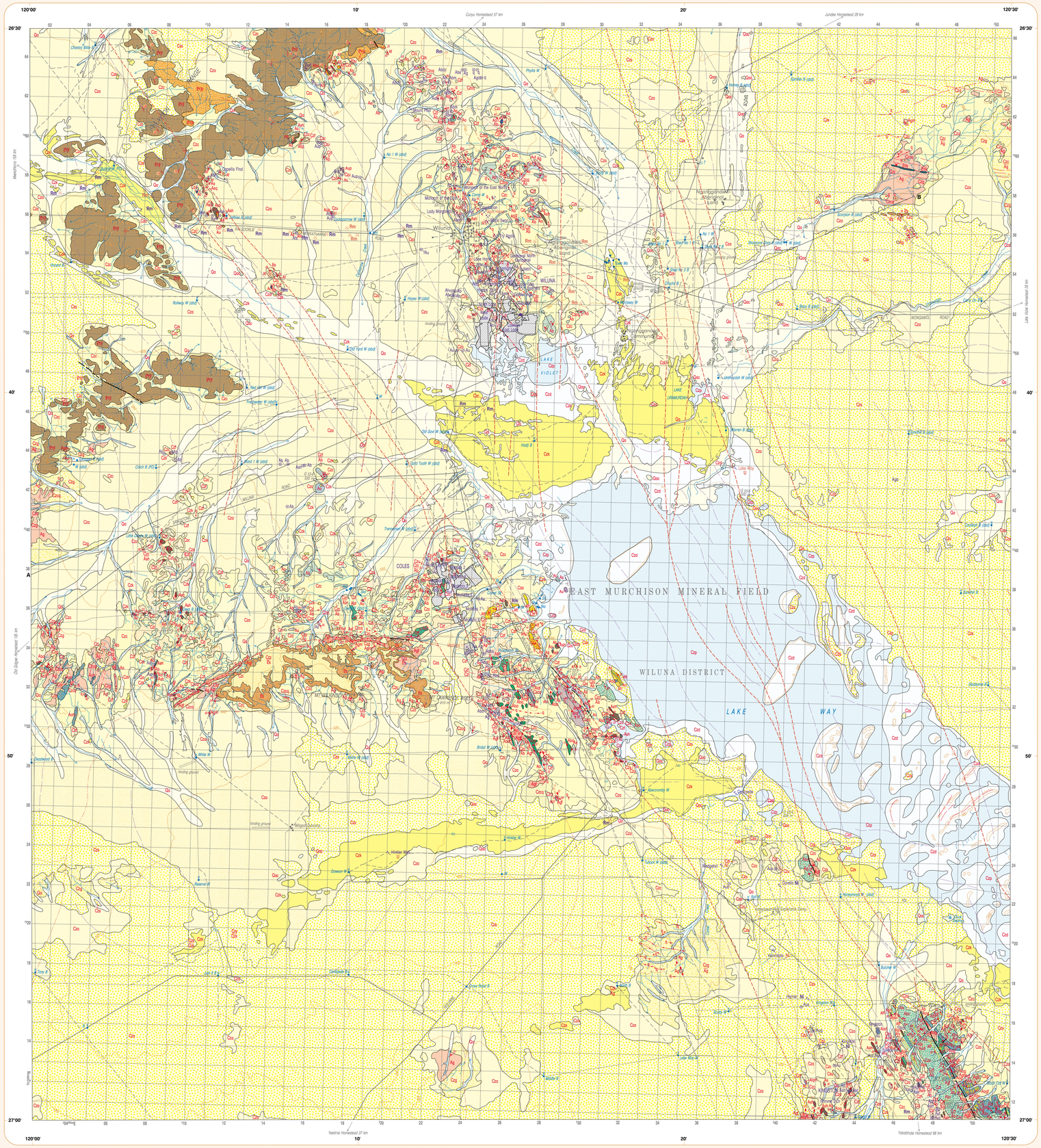
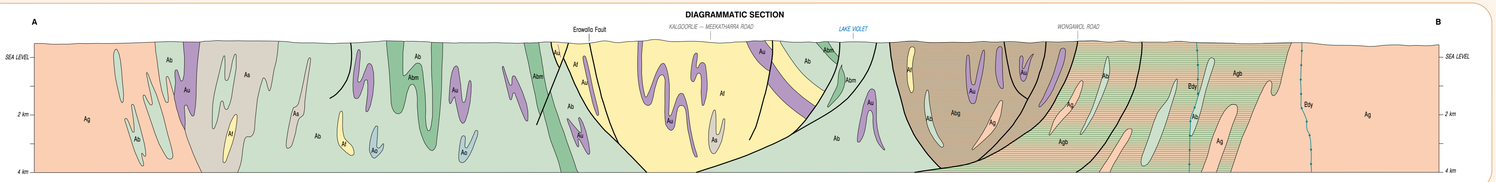


DIAGRAMMATIC SECTION



PHANEROZOIC — CAINOZOIC — QUATERNARY

Qa — *Alluvium—clay, silt, sand, and gravel in channels and floodplains
Qac — Clay and silt in claypans

Czd — Dune deposits—sand, silt, clay, and gypsum in stabilized dunes adjacent to playa lakes
Czp — Playa deposits—saline and gypsiferous evaporites, clay, and sand in playa lakes
Czs — Sheetwash deposits—clay, silt, and sand as extensive fans; commonly ferruginous
Czs — Sandplain deposits—unconsolidated sand and minor silt and clay; includes low vegetated dunes
Czc — Colluvium—gravel, sand, and silt as sheetwash and scree; includes ironstone fragments
Czcq — Quartz vein rubble and debris
Czf — Ferruginized rubble and colluvium—ferruginized rock and ironstone rubble; degraded lateritic duricrust
Czg — Sand over granitoid rock—quartzo-feldspathic sand; includes areas of low weathered outcrop

Czk — Calcrete
Czl — Lateritic deposits—lateritic duricrust, massive and nubbly; iron-rich over mafic rock
Czs — Massive ironstone as ridge and capping
Czu — Silica caprock over ultramafic rock
Czz — Silcrete

PROTEROZOIC — Yerida Group — Windplain Subgroup — YERRIDA BASIN

Es — Conglomerate, quartz-rich sandstone, arkosic sandstone, and microbial laminites; commonly silicified and brecciated

Pry — **JUDERINA FORMATION**
Finlayson Member: mature, commonly ripple-marked quartz arenite
Pry — **Bubble Well Member:** chert breccia and conglomerate; minor quartz arenite

Pdy — Mafic dyke

q — Quartz vein

Ag — Granitoid rock, undivided
Agp — Foliated granitoid rock with minor lenses of mafic rock; gneissic banding locally developed
Agf — Foliated granitoid rock
Agm — Biotite monzogranite

Ait — Chlorite schist
Aigf — Quartz-feldspar schist
Aigm — Quartz-muscovite schist

As — Metasedimentary rock, undivided; includes felsic volcanic and volcaniclastic rock
Asd — Dolomite; metamorphosed
Asf — Felsic volcaniclastic rock; metamorphosed
Ash — Shale, minor siltstone and sandstone, metamorphosed; slate, phyllite, and minor quartz-mica schist
Asq — Quartzite
Ac — Siliceous sedimentary rock and chert; mainly grey and white banded; locally ferruginous and pyritic; metamorphosed
Asi — Banded iron-formation, metamorphosed

Af — Metamorphosed felsic volcanic, and volcaniclastic rock, undivided
Aff — Foliated felsic rock; metamorphosed
Afi — Intermediate volcanic rock; metamorphosed
Afp — Porphyritic intermediate volcanic rock; metamorphosed
Afs — Felsic schist
Aft — Felsic clastic rock, probably felsic tuff; metamorphosed
Afv — Felsic volcanic and volcaniclastic rocks; metamorphosed

Ao — Metamorphosed fine-to medium-grained mafic rock, undivided
Aoh — Amphibolite, medium and coarse-grained
Aod — Microgabbro; metamorphosed
Aog — Gabbro; metamorphosed
Aogf — Strongly foliated gabbro; metamorphosed

Ab — Metamorphosed very fine-grained mafic rock, undivided
Aba — Amphibolite
Abf — Foliated, metamorphosed mafic rock; mafic schist
Abg — Mafic rock intercalated with minor foliated granitoid rock; metamorphosed
Abm — High-Mg basalt; metamorphosed
Abp — Porphyritic basalt; plagioclase phenocrysts up to 20 mm; metamorphosed (subsurface only)
Abr — Basalt intruded by gabbros; metamorphosed
Abv — Basalt, mainly tholeiitic; metamorphosed

Au — Metamorphosed ultramafic rock, undivided
Auc — Talc-carbonate(-serpentine) rock; commonly schistose (subsurface only)
Aud — Dunite; metamorphosed (subsurface only)
Auf — Interleaved ultramafic and mafic schist
Aup — Peridotite; metamorphosed
Aur — Tremolite-chlorite schist (subsurface only)
Aus — Serpentinized ultramafic rock
Aut — Talc-chlorite(-carbonate) schist

ARCHAEAN — YILGARN CRATON

Geological boundary — exposed / concealed / concealed, interpreted from aeromagnetic data
Structural symbols are numbered according to the sequence of deformation events, where known
Local deformation events — D_1 / D_2 / D_3
Fault or shear — exposed / concealed / concealed, interpreted from aeromagnetic data / strongly foliated rock
Fold, showing trend and plunge direction — anticline (Simplified Geology only) / syncline (Simplified Geology only)
Minor fold, showing trend and plunge — minor anticline / minor fold, showing plunge and nature of vergence / Z, M, or S profile
Bedding, showing strike and dip — inclined / vertical / horizontal
Way-up indicator — pillow structure / sedimentary structure
Igneous layering, showing strike and dip — inclined
Metamorphic foliation, showing strike and dip — inclined / vertical
Cleavage, showing strike and dip — inclined
Crenulation cleavage, showing strike and dip — inclined
Mineral lineation, showing plunge — plunging / horizontal
Joint, showing strike and dip — inclined
Vein, showing dip — inclined
Airphoto lineament — prominent trend, unspecified / foliation or bedding trend
Aeromagnetic lineament

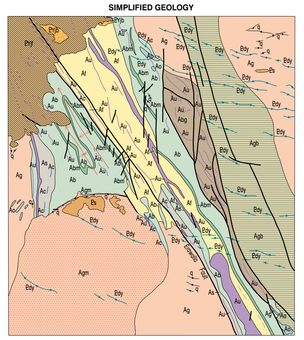
Formed road / Track / Fence, generally with track / Railway, abandoned / Powerline
Townsite, population less than 1000 — Homestead — Locality — Building — Yard
Reserve boundary / Microwave repeater station / Horizontal control, minor / Breakaway / Sand dune / Contour line, 20 metre interval

Watercourse, ephemeral — Waterhole — Soak — Pipeline — Bore — Well — Windpump — Tank — Abandoned — Position doubtful

Mining centre — Mine (gold, unless otherwise indicated) — Major opencut — Opencut — Quarry — Prospect — Treatment plant
Mining area — opencut / mods ground / tailings, mullock
Mineral exploration drillhole, shallow trench, costean, or pit showing subsurface data
Mineral occurrence — Nickel — Rood material — Uranium

WILUNA — Capella Find — West Lode — Essex

SIMPLIFIED GEOLOGY



Yerida Group — Bs — Proterozoic sedimentary rock, unassigned
Pry — Juderina Formation — Finlayson Member / Bubble Well Member — YERRIDA BASIN
Pdy — Proterozoic mafic dyke
q — Quartz vein
Ag — Agh — Agm
Ag — Granitoid rock, undivided
Agh — Granitoid rock interleaved with mafic rock
Agm — Monzogranite
As — Ac
As — Metasedimentary rocks dominant
Ac — Metamorphosed chert and banded iron-formation
Af — Metamorphosed felsic volcanic and volcaniclastic sedimentary rocks dominant
Ao — Metagabbro dominant
Ab — Abg — Abm
Ab — Metabasalt dominant
Abg — Foliated mafic greenstone interleaved with granitoid rock; metamorphosed
Abm — Metamorphosed high-Mg basalt dominant
Au — Metamorphosed ultramafic rock dominant
Aeromagnetic lineaments in Archaean rocks, overlain by Proterozoic rocks
YILGARN CRATON
SCALE 1:500 000
Kilometres

SHEET INDEX

GLENGARRY 2844	WOOLYOOLOOL 2744	MOUNT BARTLE 2644	CURYU 2544	WILUNA 2444	BALMORE 2144
		QUILENDARRY		WILUNA	
GABANINTHA 2844	YAGAHONG 2744	MERKENTHEIN 2644		LAKE VIOLET 2344	SANDALWOOD 2144
		ANGELTORN		MR SAMUEL	
NORTHAMPAH 2643	YOUNG DOWNS 2743	MONTAGU 2643	YEELIRRIE 2543	MOUNT KEITH 2443	WANGGANNOO 2143
		SG 50-16		SG 51-13	
MCCULLY 2642	SANDSTONE 2742	LAKE MASON 2542	DEPOT SPRINGS 2442	SIR SAMUEL 2342	SARLOT 2142

1:100 000 maps shown in black
1:250 000 maps shown in brown

GRID CONVERGENCE 1.3°
GRID / MAGNETIC ANGLE 0.1°
TN — GN — MN

True north, grid north and magnetic north are shown diagrammatically for the centre of the map. Magnetic north is correct for 1997 and moves easterly by about 0.1° in 2 years.

DEPARTMENT OF MINERALS AND ENERGY
L. C. RAWLINS, DIRECTOR GENERAL

GOVERNMENT OF WESTERN AUSTRALIA
HON. NORMAN MOORE, M.L.C.
MINISTER FOR MINES

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA
PETRO XU, DIRECTOR

SCALE 1:100 000
1000 0 1 2 3 4 5 6 7 8 9 10
Metres — Kilometres
TRANSVERSE MERCATOR PROJECTION
Grid lines indicate 1000 metre interval of the Australian Map Grid Zone 51

Geology by R. L. Langford and S. F. Liu 1995, F. Pirajno and N. G. Adamides 1996

Edited by C. Strong and G. Loan

Cartography by E. Green, D. Vann, and B. Williams

Topography from the Department of Land Administration Sheet SG 51-9, 2944, with modifications from geological field survey

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This map is also available in digital form

Plotted by the Geological Survey of Western Australia

The recommended reference for this map is: LANGFORD, R. L., and LIU, S. F., 1997, Wiluna, W.A. Sheet 2944. Western Australia Geological Survey, 1:100 000 Geological Series

WILUNA

SHEET 2944 **FIRST EDITION 1997** **AMENDED 1998**

Appendix F – Fauna Data

Fauna Species List

Fauna Likelihood of Occurrence Assessment

Table F.1 Fauna likelihood of occurrence

Species Name	Common name	Status		Search			Description and habitat requirements	Likelihood of occurrence
		WC Act/ DPaW	EPBC Act	Nature Map	DPaW	EPBC PMST		
Birds								
Acanthiza iredalei iredalei	Slender-billed Thornbill (western)		V			X	The western subspecies of the Slender-billed Thornbill inhabits saltbush and samphire flats, as well as chenopod shrublands that are dominated by samphires or Maireana and Atriplex associations (Morcombe 2004). Its known distribution extends from near Carnarvon in Western Australia, east though central Western Australia, and across the Nullarbor Plain to Whyalla, Port Augusta and Port Davis in South Australia. It is found throughout the Nullarbor region and other populations are confined to some of the larher ephemeral salt lakes and a band of coastal samphire on the mid-west coast. The range is fragmented, with populations on the west central coast from Lake MacLeod down to Hamelin Bay and a population on Peron Peninsula. Other populations occur on Lake Anneen and Lake Austin, Lake Barlee, Lake Ballard, Lake Way and Lake Throssell (Nevill 2008).	Unlikely There are no significant areas of suitable chenopod shrubland habitat for this species present within the Project Area. There are also no lake systems within the Project Area that would support this species.

Species Name	Common name	Status		Search			Description and habitat requirements	Likelihood of occurrence
		WC Act/ DPaW	EPBC Act	Nature Map	DPaW	EPBC PMST		
Amytornis striatus subsp. striatus	Striated Grass-wren (inland)	P4		X			The inland sub-species of the Striated Grasswren occur in spinifex, preferring big old clumps on sand dunes, and in the eastern part of the range large spinifex clumps under mallee. This sub-species has a wide range from the sandy deserts of interior WA through to mallee areas of north-western Victoria (Morcombe, 2004).	Possible There is some suitable habitat present for this species within the Project Area, consisting of spinifex sandplains. These areas appear to be mostly degraded and therefore unlikely to support a population. There are two records within 50 km of Goldfields Highway, approximately 30 km south of the highway, and 76 km south-west of Wiluna (dated 1983).
Apus pacificus	Fork-tailed Swift	IA	Mi		X	X	In south-west WA there are sparsely scattered records along the south coast, ranging from the Eyre Bird Observatory and west to Denmark. They are widespread in coastal and sub-coastal areas between Augusta and Carnarvon, including some on near-shore and offshore islands. This species is almost exclusively aerial, flying less than one metre to at least 300 m above ground. This species is considered rare in the south-west region (DotE 2013).	Unlikely The Fork-tailed Swift is known to be aerial in nature and rarely utilises terrestrial habitats. It is unlikely the habitat in the Project Area would be utilised by this species.

Species Name	Common name	Status		Search			Description and habitat requirements	Likelihood of occurrence
		WC Act/ DPaW	EPBC Act	Nature Map	DPaW	EPBC PMST		
Ardea modesta	Great Egret	IA	Mi		X	X	The Eastern Great Egret is widespread in Australia. They have been reported in a wide range of wetland habitats, include swamps and marshes; margins of rivers and lakes; damp or flooded grasslands, pasture or agricultural lands; reservoirs; sewerage treatment ponds; drainage channels; salt pans; salt marshes; mangrove, and a range of coastal/marine habitats (DotE 2013)	Unlikely There is no suitable habitat for the Great Egret within the Project Area.
Ardeotis australis	Australian Bustard	P4		X	X		The Australian Bustard occurs across much of Australia, including across most of Western Australia, except in heavily wooded areas in the south. The species is found in tussock grassland, Triodia hummock grassland, grassy woodland, and low shrublands. They will also use denser habitat that has been opened up by recent fire. They lay usually one egg, directly on the ground, typically along a boundary between open grasslands and more protective shrubland or woodlands. This species is typically widespread and nomadic, but locally scarce (Morcombe, 2004).	Present Australian Bustard prints were recorded within the Project Area during the field assessment.

Species Name	Common name	Status		Search			Description and habitat requirements	Likelihood of occurrence
		WC Act/ DPaW	EPBC Act	Nature Map	DPaW	EPBC PMST		
Burhinus grallarius	Bush Stone-curlew	P4			X		The Bush-stone Curlew inhabits dry open woodlands, lightly timbered country, mallee and mulga; anywhere with groundcover of small sparse shrubs, grass or litter of twigs. It avoids dense forest and closed canopy habitats (Morcombe 2004). In southern Australia, they persist most often where there is often a well-structured litter layer and fallen timber debris. In general, habitat occurs in open woodlands with few, if any, shrubs, and short, sparse grasses of less than 15 cm in height, with scattered fallen timber, leaf litter and bare ground present. Overall the important structural elements of Bush Stone-curlew habitat appear to be low sparse ground cover, some fallen timber and leaf litter, a general lack of a shrubby understory and open woodlands.	Present One Bush Stone-curlew individual was recorded on camera trap 4, located at the dam on the north side of the highway, during the field survey.
Cacatua leadbeateri	Major Mitchell's Cockatoo	S		Not recorded in desktop searches but known to occur in the region.			Major Mitchell's Cockatoo occurs in open sparsely timbered grasslands, drier farmlands with well-treed paddocks, mulga and similar open scrublands, open mallee country, callitris and casuarina country, watercourse trees and is never far from water (Morcombe 2004). The main requirements of the species are trees with suitable nesting hollows and fresh surface water.	Possible While the Major Mitchell's Cockatoo was not recorded during the desktop searches or the field survey, the Project Area does occur within the species known range and there are some small areas of suitable habitat, particularly around the Bubble Creek area.

Species Name	Common name	Status		Search			Description and habitat requirements	Likelihood of occurrence
		WC Act/ DPaW	EPBC Act	Nature Map	DPaW	EPBC PMST		
Charadrius veredus	Oriental Plover	IA	Mi		X	X	The Oriental Plover is a non-breeding visitor to Australia, where the species occurs in both coastal and inland areas, mostly in northern Australia. Most records are along the north-western coast, between Exmouth Gulf and Derby in Western Australia, and there are records at a few scattered sites elsewhere, mainly along the northern coast, such as in the Top End, the Gulf of Carpentaria and on Cape York Peninsula. The species also often occurs further inland on the 'blacksoil' plains of northern Western Australia, the Northern Territory and north-western Queensland. It is seldom recorded in southern Australia. The species does not breed in Australia (Morcombe 2004).	Unlikely The Oriental Plover has been recorded within 20 km of the Project Area, however there is no suitable habitat for the species present.
Falco hypoleucos	Grey Falcon	T		Not recorded in desktop searches, but found to be present during field survey.			The Grey Falcon inhabits lightly timbered country, especially stony plains and lightly timbered acacia scrub. This species is considered scarce to rare and is usually found singularly or sometimes in pairs (Morcombe, 2004).	Present One Grey Falcon individual was observed within Acacia shrubland in the Project Area during the field survey.
Falco peregrinus macropus	Peregrine Falcon	S		X	X		The Peregrine Falcon is seen occasionally anywhere in the south-west of Western Australia. It is found everywhere from woodlands to open grasslands and coastal cliffs - though less frequently in desert regions. The species nests primarily on ledges of cliffs, shallow tree hollows, and ledges of building in cities. (Morcombe, 2004).	Likely The Peregrine Falcon is known to occur in the region and is likely to use the Project Area opportunistically. There are no nesting areas for this species present within the Project Area.

Species Name	Common name	Status		Search			Description and habitat requirements	Likelihood of occurrence
		WC Act/ DPaW	EPBC Act	Nature Map	DPaW	EPBC PMST		
Leipoa ocellata	Malleefowl	T	V, Mi	X	X		The Malleefowl generally occurs in semi-arid areas of Western Australia, from Carnarvon to south east of the Eyre Bird Observatory (south-east Western Australia). It occupies shrublands and low woodlands that are dominated by mallee vegetation, as well as native pine Callitris woodlands, Acacia shrublands, Broombush (Melaleuca uncinata) vegetation or coastal heathlands. The nest is a large mound of sand or soil and organic matter (Jones and Goth 2008; Morcombe, 2004). They prefer vegetation with a dense understorey of shrubs and their breeding habitat is characterized by light soil and abundant leaf litter, which is used in the construction of nesting mounds. Density of the canopy cover is an important feature associated with high breeding densities, while grazed areas generally have much lower densities. In the WA Wheatbelt, Malleefowl distribution is associated with landscapes with lower rainfall, greater amounts of mallee and shrubland that occur as large remnants, and lighter soil surface textures.	Likely There is suitable habitat for the Malleefowl within the Project Area and the species has previously been recorded approximately halfway between Meekatharra and Wiluna in 2010. It is likely that the region is sparsely populated with the species as the Project Area is located at the northern extent of its range. In addition there have also been multiple records (sightings, tracks and mounds) in 2006-7 of Malleefowl, approximately 20 km south of Goldfields Highway, just north of the Sandstone Wiluna Road. No evidence of Malleefowl was recorded within the Project Area during the field survey, however two historic mounds were recorded approximately 14 km south.

Species Name	Common name	Status		Search			Description and habitat requirements	Likelihood of occurrence
		WC Act/ DPaW	EPBC Act	Nature Map	DPaW	EPBC PMST		
Merops ornatus	Rainbow Bee-eater	IA	Mi	X	x	X	Open forests and woodlands, shrublands, and in various cleared or semi-cleared habitats, including farmland and areas of human habitation. It also inhabits sand dune systems in coastal areas and at inland sites that are in close proximity to water (Morcombe, 2004).	Present Rainbow Bee-eaters were sighted within the Project Area during the field assessment.
Polytelis alexandrae	Princess Parrot	P4	V			X	The Princess Parrot is confined to arid regions of Western Australia, the Northern Territory, and South Australia. The Princess Parrot inhabits sand dunes and sand flats in the arid zone of western and central Australia. It occurs in open savanna woodlands and shrublands that usually consist of scattered stands of Eucalyptus (including E. gongylocarpa, E. chippendalei and mallee species), Casuarina or Allocasuarina trees; an understorey of shrubs such as Acacia (especially A. aneura), Cassia, Eremophila, Grevillea, Hakea and Senna; and a ground cover dominated by Triodia species. It also frequents Eucalyptus or Allocasuarina trees in riverine or littoral areas.	Unlikely The Princess Parrot is typically found in the central desert region around Giles, Warburton and in the Great Sandy Desert. There are no records of the species within 50 km of the Project Area, and the closest historical record is from the Kumarina area in 1919. Therefore it is considered unlikely to occur.

Species Name	Common name	Status		Search			Description and habitat requirements	Likelihood of occurrence
		WC Act/ DPaW	EPBC Act	Nature Map	DPaW	EPBC PMST		
Tyto novaehollandiae subsp. novaehollandiae	Masked Owl (southern subsp)	P3		X	X		The Masked Owl is found across a range of habitats from wet sclerophyll forest, dry sclerophyll forest, non-eucalypt dominated forest, scrub and cleared land with remnant old growth trees. There are however several aspects of habitat preference which appear to be common: the Masked Owl requires large hollows in old growth eucalypts for nesting; it often favours areas with dense understorey or ecotones comprising dense and sparse ground cover, they are often recorded foraging within 100-300 m of the boundary of two vegetation types (Bell & Mooney, 2002).	Unlikely The NatureMap record of this species is likely to be an error as the southern subspecies of the Masked Owl is restricted to south-west corner of WA.
Mammals								
Dasycercus blythi	Brush-tailed Mulgara	P4			X		The Brush-tailed Mulgara is primarily nocturnal, shelters in burrows and feeds on insects, other arthropods and small vertebrates. This species inhabits spinifex grasslands and, in central Australia, lives in burrows that it digs on the flats between low sand dunes (Van Dyck and Strahan 2008). The Mulgara is a solitary species exhibiting high site fidelity and a low propensity for dispersal once a home range has been established (Masters and Crowther 2003). Males and females maintain home ranges of 1.4 to 14 hectares (Masters and Crowther 2003) which on average, overlap by less than 20% (Masters and Crowther 2003).	Likely to be present Mulgara active burrows, old burrows, scats and tracks were recording throughout the spinifex dominated areas of the Project Area during the field survey. Based on the findings of Woolley et al. (2013) and the information presented during the DPaW Mulgara workshop (11/12/13), it is likely that this evidence is of Brush-tailed Mulgara. There also is a record of the species 40 km north-east of Wiluna (record by Pat Woolley).

Species Name	Common name	Status		Search			Description and habitat requirements	Likelihood of occurrence
		WC Act/ DPaW	EPBC Act	Nature Map	DPaW	EPBC PMST		
Dasycercus cristicauda	Crest-tailed Mulgara	T	V	X	X		In recent times the Crest-tailed Mulgara has been found in the southern Simpson Desert where the borders of the NT, Qld and SA converge and in the Tirari and Strzelecki Deserts of SA. Historic records indicate that it once occurred on the Canning Stock Route and Nullarbor Plain in WA. The Crest-tailed Mulgara inhabits the inland sandy deserts of central Australia, primarily amongst Spinifex grasslands. The species is found on sand dunes with a sparse cover of Sandhill Canegrass (Zygochloa paradoxa) or areas around salt lakes with Nitre Bush (Nitraria billardieri) (Woolley 2005). This contrasts with the habitat of the Brush-tailed Mulgara, which is generally spinifex grasslands with medium to dense cover (Van Dyck and Strahan 2008). Burrows occur predominantly on the dunes, mostly at the base of large Canegrass clumps or Nitre Bush hummocks.	Unlikely There are three records of the Crest-tailed Mulgara from one location approximately 10 km south of the Goldfields Highway in 2007. Based on the findings of Woolley et al. (2013) and the information presented during the DPaW Mulgara workshop (11/12/13), it is likely that these are misidentified records and they actually represent the Brush-tailed Mulgara. In addition, Crest-tailed Mulgara records are typically from sand dune habitats, of which there is only one limited area in the Project Area.

Species Name	Common name	Status		Search			Description and habitat requirements	Likelihood of occurrence
		WC Act/ DPaW	EPBC Act	Nature Map	DPaW	EPBC PMST		
Macrotis lagotis	Greater Bilby	T	V	X	X		The Greater Bilby occupies three major vegetation types; open tussock grassland on uplands and hills, mulga woodland/shrubland growing on ridges and rises, and hummock grassland in plains and alluvial areas. In the south of its range, the Greater Bilby lives on rises and ridges among sparse grasses, especially mitchell grass Astrebla and short shrubs. In Western Australia there are disjunct populations in the Gibson Desert, south-western Kimberley, inland areas of the Pilbara and northern Great Sandy Desert.	Unlikely Historical Greater Bilby records are known from the Wiluna area (1927-8, 1984), however as the region has pastoral use and has been heavily degraded, it unlikely that the Bilby still occurs in the region. During the field survey 28 Bilby Search Areas were undertaken, and some old potential burrows were recorded. However no active burrows were recorded and the species was not recorded on any of the camera traps.

Species Name	Common name	Status		Search			Description and habitat requirements	Likelihood of occurrence
		WC Act/ DPaW	EPBC Act	Nature Map	DPaW	EPBC PMST		
Notoryctes caurinus	Northern Marsupial Mole	T	En			X	The Northern Marsupial Mole lives underground, primarily in sand dunes and sandy soils along river flats. It occasionally comes to the surface, apparently more frequently after rain. Underground signs of marsupial moles are usually found on well-vegetated dunes (where prey may be more abundant) and generally not in swales (flats between dunes). It is thought that this may be due to the sand between dunes being too compact for the animal to effectively move through. The vegetation in Northern Marsupial Mole habitat is generally Acacia spp., small shrubs and Desert Oak (Allocasuarina decaisneana) and often (but not always) associated with spinifex (Triodia spp.). Sandy river flats are also thought to be potential Northern Marsupial Mole habitat, as they are rich in food resources and may act as dispersal corridors. The Northern Marsupial Mole cannot safely travel far over hard ground, so connectivity of dune habitat is likely to be important for maintaining the species' range and successful dispersal. Underground signs are generally found between 20 to 100 cm below the dune surface (DotE 2013).	Unlikely There is only one small sand dune system within the Project Area (north side of the highway at SLK 732) that would provide suitable habitat for the Northern Marsupial Mole. Given the isolated nature of this system, it is unlikely that the species occurs there. However, given the difficulty in detecting the species it remains unknown. Records of this species are predominantly known from the Little Sandy Desert, Great Sandy Desert and Gibson Desert regions of WA.

Species Name	Common name	Status		Search			Description and habitat requirements	Likelihood of occurrence
		WC Act/ DPaW	EPBC Act	Nature Map	DPaW	EPBC PMST		
Rhinonicteris aurantia (Pilbara form)	Pilbara Leaf-nosed Bat	T	V			X	The Pilbara Leaf-nosed Bat,is restricted to the Pilbara region and field surveys suggest that it is divided into three discrete subpopulations (eastern Pilbara mines and granite, Hamersley Range, Upper Gascoyne). The Pilbara Leaf-nosed Bat is restricted to caves and mine adits (horizontal shafts) with stable, warm and humid microclimates because of its poor ability to thermoregulate and retain water. The roost is usually over pools of water in deeper mines, or deep within the mine or cave structure in an area that maintains elevated temperature and humidity. Thus, the roosting site is often at depth in mines; in small crevices within caves, usually those ascending between sedimentary rock layers; and with associated groundwater seeps. In the Pilbara few actual roost clusters have been observed, perhaps the only one being that in the Comet mine prior to 1992. Simple vertical shafts are not used and shallow caves beneath mesa bluffs are also unlikely roost sites.	Unlikely The Pilbara Leaf-nosed Bat has not been recorded in the Mid-West region, and the closest record of the species is located 250 km north of the Project Area (1999).

Species Name	Common name	Status		Search			Description and habitat requirements	Likelihood of occurrence
		WC Act/ DPaW	EPBC Act	Nature Map	DPaW	EPBC PMST		
Sminthopsis longicaudata	Long-tailed Dunnart	P4		X	X		Sparse records exist for this species which are rare and scattered, however it may be locally common at times. In winter the Long-tailed Dunnart feeds on arthropods: mainly beetles and ants, but also spiders, cockroaches, centipedes, grasshoppers, flies and various larvae. This species appears to be a spring-summer breeder. The records of the Long-tailed Dunnart come from widely scattered localities in the arid zone where it inhabits rugged, rocky areas. These areas include scree slopes, boulder and stony plateaus, and adjacent stony plains with shrubs over spinifex grasslands (Van Dyck et al. 2013)	Likely There are some small areas of suitable rocky habitat for the Long-tailed Dunnart within the Project Area. There are also two records of the species approximately 30 km south-west of Wiluna from 2011.
Reptiles								
Lerista eupoda	Good-legged Lerista skink	P1		X			Occurs in open Mulga areas on loamy soils in the arid southern interior of Western Australia, between Meekatharra and Cue (Wilson and Swan 2013).	Likely There is suitable Mulga habitat is present within the Project Area, particularly towards the Meekatharra end of the highway. The closest record of the species is located approximately 32 km south-west of Meekatharra at Nannine in 1994.

Species Name	Common name	Status		Search			Description and habitat requirements	Likelihood of occurrence
		WC Act/ DPaW	EPBC Act	Nature Map	DPaW	EPBC PMST		
Liopholis kintorei	Great Desert Skink	T	V			X	The Great Desert Skink generally occurs on red sandplains and sand ridges. Populations in the Gibson Desert occur on sandplains with a surface cover of fine gravel. Vegetation usually consists of hummock grassland (Triodia basedowii, Triodia pungens and Triodia schinzii), with some scattered shrubs and occasional trees (e.g. Acacia spp., Eucalyptus spp., Hakea spp., Grevillea spp. and Allocasuarina decaisneana). Sites in WA are dominated by Triodia basedowii and Triodia schinzii with some Eremophila leucophylla shrubs. The population at Patjarr WA occurs on a gravelly undulating plain with scattered Black Gidgee (Acacia pruinocarpa) or Mulga over Triodia basedowii and low shrubs. Regenerating vegetation appears to be a critical habitat requirement. Skinks appear to prefer a mosaic landscape of different aged vegetation and inhabit sites that have been burnt in the previous three to fifteen years.	Unlikely There is no suitable habitat for the Great Desert Skink within the Project Area and the nearest record of the species is 100 km south-east of Wiluna. This is a historical record from 1964.

Species Name	Common name	Status		Search			Description and habitat requirements	Likelihood of occurrence
		WC Act/ DPaW	EPBC Act	Nature Map	DPaW	EPBC PMST		
Egernia stokesii badia	Western Spiny-tailed Skink	T	En	Not recorded in desktop searches but known to occur in the region.			The Western Spiny-tailed Skink occurs in open eucalypt woodlands and Acacia-dominated shrublands in semi-arid to arid areas of south-western Western Australia. The 'black from' populations of this species occur in granite outcrops and lateritic breakaways in the Cue-Yalgoo-Mt Magnet region. Individuals of the 'black form' live on granite outcrops and ironstone breakaways and shelters in horizontal crevices and under boulders (DotE 2013).	Unlikely The 'black form' populations of the Western Spiny-tailed Skink are restricted to an area approximately bounded by Yalgoo, Mt. Magnet, Cue and Murchison Settlements. There is suitable scattered granite outcrop habitat for this species within the Project Area and the closest record is approximately 133 km south-west of Meekatharra. It is therefore unlikely that the 'black form' occurs within the Project Area.

Legend:

EPBC Act	Federal *Environment Protection and Biodiversity Conservation Act 1999*
WC Act	State *Wildlife Conservation Act 1850*
PMST	EPBC Act Protected Matters Search Tool
DPaW	Department of Parks and Wildlife
T	Threatened (Schedule 1 under the WC Act)
IA	Birds protected under international agreement (Schedule 3 under the WC Act)
S	Other Specially Protected Fauna (Schedule 4 under the WC Act)
En	Endangered (EPBC Act)

V	Vulnerable (EPBC Act)
Mi	Migratory (EPBC Act)
P	Priority (listed by DPaW)

References:

Bell, P.J. and Mooney, N. (2002). Distribution, Habitat and Abundance of Masked Owls (Tyto novaehollandiae) in Tasmania, In; *Ecology and Conservation of Owls*, Eds. Newton I., Kavanagh R., Olsen J., and Taylor I., CSIRO Publishing, Australia.

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Appendix G – Noise terminology

Description of Noise Terms

Chart of Noise Level Descriptors

Typical Noise Levels

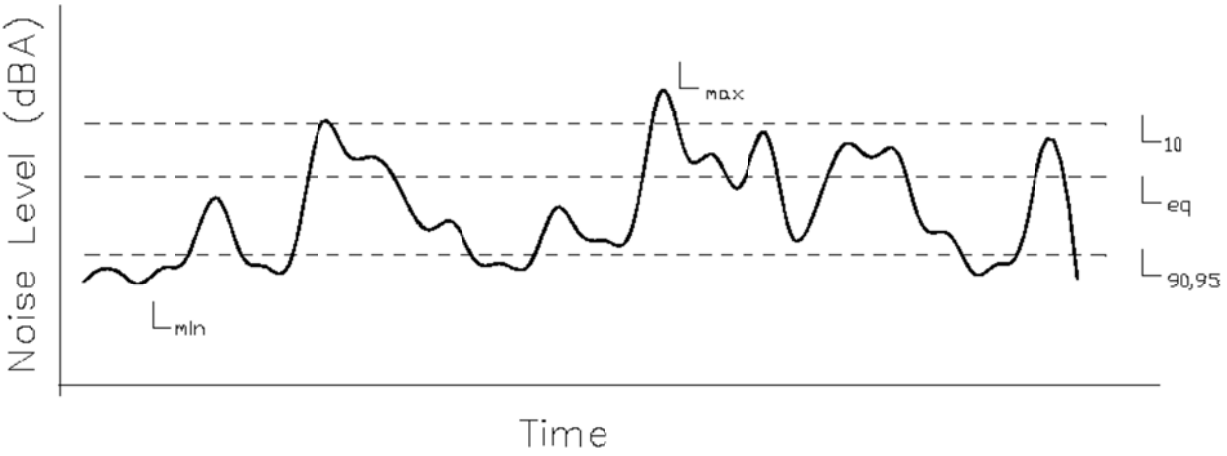
Table G.1 Description of noise terms

Term	Definition
Ambient noise	Level of noise from all sources, including background noise from near and far and the source of interest.
A-weighted	A-weighted noise level has been filtered in such a way as to represent the way in which the human ear perceives sound. This weighting reflects the fact that the human ear is not as sensitive to lower frequencies as it is to higher frequencies. A-weighted sound level is described as LA dB.
Background noise	Noise level from sources other than the source of concern.
dB	Decibel is the unit that describes the sound pressure and sound power levels of a noise source. It is a logarithmic scale referenced to the threshold of hearing.
dBA	Unit used to measure 'A-weighted' sound pressure levels.
Hz	Units for frequency are known as Hertz.
Impulsive noise	An impulsive noise source has a short-term banging, clunking or explosive sound. The quantitative definition of impulsiveness is: A variation in the emission of a noise where the difference between LA Peak and LA Max Slow is more than 15 dB when determined for a single representative event.
LA Slow	This is the noise level in decibels, obtained using A-weighting and S time weighting as specified in AS1259.1-1990. Unless assessing modulation, all measurements use the slow time weighting characteristic.
LA Fast	This is the noise level in decibels, obtained using A-weighting and F time weighting as specified in AS1259.1-1990. This is used when assessing the presence of modulation only.
LA Peak	This is the maximum reading in decibels using A-weighting and P time weighting as specified in S1259.1-1990.
LA Max	LA Max level is the maximum A-weighted noise level during a particular measurement.
LA 1	LA 1 level is the A-weighted noise level which is exceeded for 1% of the measurement period and is considered to represent the average of the maximum noise levels measured.
LA 10	LA 10 level is the A-weighted noise level which is exceeded for 10% of the measurement period and is considered to represent the intrusive noise level.
LA 90	LA 90 level is the A-weighted noise level which is exceeded for 90% of the measurement period and is considered to represent the background noise level.
LA Eq	The equivalent steady state A-weighted sound level ('equal energy') in decibels which, in a specified time period, contains the same acoustic energy as the time-varying level during the same period. It is considered to represent the average noise level.
LA Max assigned level	Means an assigned level which, measured as a LA Slow value, is not to be exceeded at any time.
LA 1 assigned level	Means an assigned level which, measured as a LA Slow value, is not to be exceeded for more than one percent of the representative assessment period.
LA 10 assigned level	Means an assigned level which, measured as a LA Slow value, is not to be exceeded for more than 10% of the representative assessment period.

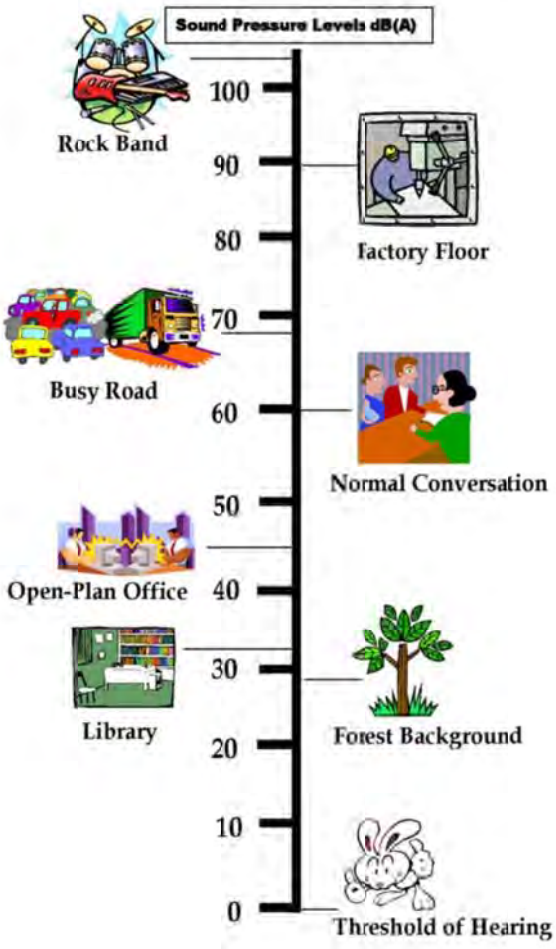
Term	Definition
Linear	Sound levels measured without any weightings are referred to as 'linear' and the units are expressed as dB(lin).
L linear, peak	Maximum reading in decibels obtained using P-time-weighting characteristic as specified in AS 1259.1-1990.
Maximum design sound level	The level of noise above which most people occupying the space start to become dissatisfied with the level of noise.
Modulating noise	A modulating source is regular, cyclic and audible and is present for at least 10% of the measurement period. The quantitative definition of modulation is: A variation in the emission of noise that - • Is more than three dB LA Fast or is more than three dB LA Fast in any one-third octave band • Is present for at least 10% of the representative assessment period • Is regular, cyclic and audible
One-third octave band	Means a band of frequencies spanning one-third of an octave and having a centre frequency between 25 Hz and 20,000 Hz inclusive.
Rating background level (RBL)	The overall single-figure background level representing each assessment period (day/evening/night) over the whole monitoring period (as opposed to over each 24-hour period used for the assessment background level). This is the level used for assessment purposes. It is defined as the median value of: All the day assessment background levels over the monitoring period for the day (7:00 am to 6:00 pm) All the evening assessment background levels over the monitoring period for the evening (6:00 pm to 10:00 pm) All the night assessment background levels over the monitoring period for the night (10:00 pm to 7:00 am)
Representative assessment period	Means a period of time not less than 15 minutes and not exceeding four hours, determined by an inspector or authorised person to be appropriate for the assessment of a noise emission, having regard to the type and nature of the noise emission.
Reverberation time	Of an enclosure, for a sound of a given frequency or frequency band, the time that would be required for the reverberantly decaying sound pressure level in the enclosure to decrease by 60 decibels.
RMS	Root mean square level; used to represent the average level of a wave form such as vibration.
Satisfactory design sound level	The level of noise that has been found to be acceptable by most people for the environment in question and also to be not intrusive.
Sound pressure level (LP)	The sound pressure level of a noise source is dependent upon its surroundings (influenced by distance, ground absorption, topography, meteorological conditions etc) and is what the human ear actually hears. Noise modelling predicts the sound pressure level from the sound power levels taking into account ground absorption, barrier effects, distance etc.
Sound power level (LW)	Under normal conditions, a given sound source will radiate the same amount of energy, irrespective of its surroundings, being the sound power level. The sound power level of a noise source cannot be directly measured using a sound level meter but is calculated based on measured sound pressure levels at known distances. Noise modelling incorporates source sound power levels as part of the input data.

Term	Definition
Specific noise	Relates to the component of the ambient noise that is of interest. This can be referred to as the noise of concern or the noise of interest
Tonal noise	A tonal noise source can be described as a source that has a distinctive noise emission in one or more frequencies. An example would be whining or droning. The quantitative definition of tonality is: The presence in the noise emission of tonal characteristics where the difference between - The A-weighted sound pressure level in any one-third octave band The arithmetic average of the A-weighted sound pressure levels in the two adjacent one-third octave bands is greater than three dB when the sound pressure levels are determined as LA eq,T levels where the time period T is greater than 10% of the representative assessment period, or greater than 8 dB at any time when the sound pressure levels are determined as LA Slow levels. This is relatively common in most noise sources.
Vibration velocity level	The RMS velocity of a vibration source over a specified time period, measured in mm/s.

Chart of noise level descriptors



Typical noise levels



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