ROBE
A member of the Rio Tinto Group

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Office of the Environmental Protection Authority
File:
11 DEC 2014
A: For Information
fa: For Discussion
Officer: For Action
Dir.AC
Dir. Bus Ops
Dir. SPPD
Dir. Strat Sup
Response please:
GM Signature
Dir for GM (copy to GM)
Dir Signature (copy to GM)
Mgr Direct (copy to GM)

Mr Anthony Sutton
Director, Assessment and Compliance Division
Office of the Environmental Protection Authority
The Atrium, 168 St Georges Terrace
Locked Bag 10,
East Perth WA 6892

Our Ref: RTIO-HSE-0236390

3 December 2014

Attention: Peter Tapsell

Dear Mr Sutton

**WEST ANGELAS DEPOSIT A WEST AND DEPOSIT F, SECTION 38 REFERRAL APPLICATION AND REVISED PROPOSAL**

The enclosed document is a submission by Robe River Mining Co. Pty. Ltd. (the **Proponent**) under section 38 of the *Environmental Protection Act 1986* (**EP Act**) for the following:

- Mining of iron ore from above and below the water table in Deposit A west and Deposit F (the **Proposal**).
- A revision to Ministerial Statement 970 to include the Proposal.

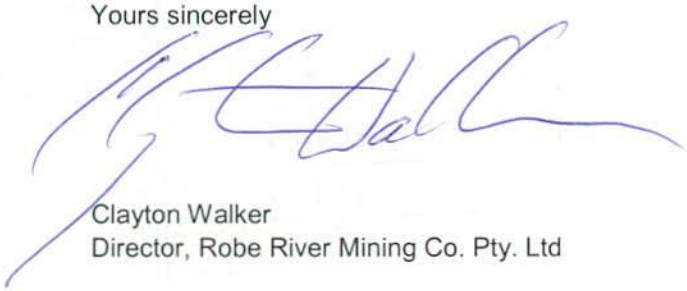
A revised Ministerial Statement is included for consideration. The Proponent proposes that this project is a revision to, and supersedes Ministerial Statement 970 (12 June 2014).

Therefore, please find enclosed:

- a completed Proponent Referral Form;
- a supporting *West Angelas Revised Proposal, Deposit A west and Deposit F Assessment on Proponent Information Environmental Review Document*, dated September 2014. This document provides additional detail on the scope of the Proposal, the studies undertaken, the stakeholder consultation program and the key aspects and proposed management strategies for the Proposal; and
- a CD containing the Proponent Referral Form, the Environmental Review Document, the appendices and the spatial data for the Revised Proposal.

If you require any further information in relation to the Proposal please do not hesitate to contact Carly Nixon on 6213 1297 in the first instance.

Yours sincerely



Clayton Walker
Director, Robe River Mining Co. Pty. Ltd

Environmental Protection Authority

GOVERNMENT OF WESTERN AUSTRALIA

EPA REFERRAL FORM PROPONENT

# Referral of a Proposal by the Proponent to the Environmental Protection Authority under Section 38(1) of the *Environmental Protection Act 1986*.

## PURPOSE OF THIS FORM

Section 38(1) of the *Environmental Protection Act 1986* (EP Act) provides that where a development proposal is likely to have a significant effect on the environment, a proponent may refer the proposal to the Environmental Protection Authority (EPA) for a decision on whether or not it requires assessment under the EP Act. This form sets out the information requirements for the referral of a proposal by a proponent.

Proponents are encouraged to familiarise themselves with the EPA's *General Guide on Referral of Proposals* [see Environmental Impact Assessment/Referral of Proposals and Schemes] before completing this form.

A referral under section 38(1) of the EP Act by a proponent to the EPA must be made on this form. A request to the EPA for a declaration under section 39B (derived proposal) must be made on this form. This form will be treated as a referral provided all information required by Part A has been included and all information requested by Part B has been provided to the extent that it is pertinent to the proposal being referred. Referral documents are to be submitted in two formats – hard copy and electronic copy. The electronic copy of the referral will be provided for public comment for a period of 7 days, prior to the EPA making its decision on whether or not to assess the proposal.

## CHECKLIST

Before you submit this form, please check that you have:

| | Yes | No |
|---|---|---|
| Completed all the questions in Part A (essential). | ✓ | |
| Completed all applicable questions in Part B. | ✓ | |
| Included Attachment 1 – location maps. | ✓ | |
| Included Attachment 2 – additional document(s) the proponent wishes to provide (if applicable). | ✓ | |
| Included Attachment 3 – confidential information (if applicable). | | |
| Enclosed an electronic copy of all referral information, including spatial data and contextual mapping but excluding confidential information. | ✓ | |

Following a review of the information presented in this form, please consider the following question (a response is optional).

| Do you consider the proposal requires formal environmental impact assessment? | | |
|---|---|---|
| ☒ Yes | ☐ No | ☐ Not sure |
| If yes, what level of assessment? | | |
| ☒ Assessment on Proponent Information | ☐ Public Environmental Review | |

**PROPONENT DECLARATION** (to be completed by the proponent)

I, Clayton Walker, declare that I am authorised on behalf of Robe River Mining Co. Pty. Ltd to submit this form and further declare that the information contained in this form is true and not misleading.

| | |
|---|---|
| Signature:  | Name (print): Clayton Walker |
| Position: Director | Company: Robe River Mining Co. Pty. Ltd. |
| Date: 5 December 2014 | |

## PART A - PROPONENT AND PROPOSAL INFORMATION

(All fields of Part A must be completed for this document to be treated as a referral)

## 1 PROPONENT AND PROPOSAL INFORMATION

### 1.1 Proponent

| | |
|---|---|
| Name | Robe River Mining Co. Pty. Ltd. |
| Joint Venture parties (if applicable) | Robe River Joint Venture Participants |
| Australian Company Number (if applicable) | 71 008 694 246 |
| Postal Address<br>(where the proponent is a corporation or an association of persons, whether incorporated or not, the postal address is that of the principal place of business or of the principal office in the State) | GPO Box A42<br>Perth WA 6837 |
| Key proponent contact for the proposal:<br>• name<br>• address<br>• phone<br>• email | Carly Nixon<br>Environmental Approvals Specialist<br>GPO Box A42<br>Perth WA 6837<br>T: +61 (08) 6213 1297<br>carly.nixon@riotinto.com |
| Consultant for the proposal (if applicable):<br>• name<br>• address<br>• phone<br>• email | NA |

### 1.2 Proposal

| | |
|---|---|
| Title | West Angelas Deposit A west and Deposit F Revised Proposal. |
| Description | The Proponent, Robe River Mining Co. Pty. Ltd., on behalf of the Robe River Joint Venture Participants, proposes to mine iron ore from above and below the water table at Deposits A west and F, as satellite deposits to the existing West Angelas mining operations. Once mined, ore will be transported by haul trucks to existing processing facilities. |
| Extent (area) of proposed ground disturbance. | The Proposal will require clearing of approximately 3,220 ha.<br><br>This referral is not seeking approval for activities already authorised as part of the existing operations. |

| | |
|---|---|
| Timeframe in which the activity or development is proposed to occur (including start and finish dates where applicable). | Production commenced at the existing West Angelas mining operations in 2001 at Deposit A and in 2011 at Deposit E. Deposit A provides the primary ore source with Deposit E supplementing the production to maintain the current production rate. Deposit B is the next major ore source with mining scheduled to commence in 2015. Production from all existing deposits will decline from 2016. An additional ore source is therefore required to sustain current production from the West Angelas Project. Deposits A west and F have been identified as the next to be developed in the conceptual long term development strategy.<br><br>Robe proposes to commence mining of Deposits A west and F in 2016. |
| Details of any staging of the proposal. | The Proposal is not staged. |
| Is the proposal a strategic proposal? | No. |
| Is the proponent requesting a declaration that the proposal is a derived proposal? | No. |
| Please indicate whether, and in what way, the proposal is related to other proposals in the region. | Deposits A west and F will be developed as satellite deposits to the existing West Angelas mining operations. |
| Does the proponent own the land on which the proposal is to be established? If not, what other arrangements have been established to access the land? | The West Angelas Iron Ore Mine is located on Mineral Lease 248SA (AML248SA) which was granted in 1976 under the *Iron Ore (Robe River) Agreement Act 1964*. The infrastructure associated with the West Angelas mining operations is located on a number of Miscellaneous Licences and General Purpose Leases that were granted under the *Mining Act 1978*. The Leases are held under the Robe River Joint Venture which is managed on behalf of the partners by Robe River Mining Co. Pty. Ltd.<br><br>The current tenure is appropriate tenure for all current and proposed mining activities and mining related infrastructure. |
| What is the current land use on the property, and the extent (area in hectares) of the property? | The location of West Angelas is very remote, with no neighbouring mining or pastoral activities. |

## 1.3 Location

| | |
|---|---|
| Name of the Shire in which the proposal is located. | The Proposal is located in the Shire of East Pilbara. |
| For urban areas:<br>• street address;<br>• lot number;<br>• suburb; and<br>• nearest road intersection. | NA. |
| For remote localities:<br>• nearest town; and<br>• distance and direction from that town to the proposal site. | The West Angelas Iron Ore Mine is located approximately 130 kilometres (km) northwest of Newman in the Pilbara region of Western Australia. |
| Electronic copy of spatial data - GIS or CAD, geo-referenced and conforming to the following parameters:<br>• GIS: polygons representing all activities and named;<br>• CAD: simple closed polygons representing all activities and named;<br>• datum: GDA94;<br>• projection: Geographic (latitude/longitude) or Map Grid of Australia (MGA);<br>• format: Arcview shapefile, Arcinfo coverages, Microstation or AutoCAD. | Enclosed?: **Yes.** |

## 1.4 Confidential Information

| | |
|---|---|
| Does the proponent wish to request the EPA to allow any part of the referral information to be treated as confidential? | No. |
| If yes, is confidential information attached as a separate document in hard copy? | NA. |

## 1.5 Government Approvals

| | | | |
|---|---|---|---|
| Is rezoning of any land required before the proposal can be implemented?<br>If yes, please provide details. | | No. | |
| Is approval required from any Commonwealth or State Government agency or Local Authority for any part of the proposal?<br>If yes, please complete the table below. | | Yes. | |
| Agency/Authority | Approval required | Application lodged Yes / No | Agency/Local Authority contact(s) for proposal |

| | | | |
|---|---|---|---|
| Minister for Environment; Environmental Protection Authority<br>(EPA) | *Environmental Protection Act 1986* (WA) - Part IV: Ministerial Statement | Purpose of this document | EPA<br>The Atrium<br>168 St Georges Tce<br>PERTH WA 6000 |
| Department of Water<br>(DoW) | *Rights in Water and Irrigation Act 1914 (WA):* Licenses to Construct Wells and Take Water | No | DoW<br>The Atrium<br>168 St Georges Tce<br>PERTH WA 6000 |

## PART B - ENVIRONMENTAL IMPACTS AND PROPOSED MANAGEMENT

### 2. ENVIRONMENTAL IMPACTS

Describe the impacts of the proposal on the following elements of the environment, by answering the questions contained in Sections 2.1-2.11:

2.1 flora and vegetation;

2.2 fauna;

2.3 rivers, creeks, wetlands and estuaries;

2.4 significant areas and/ or land features;

2.5 coastal zone areas;

2.6 marine areas and biota;

2.7 water supply and drainage catchments;

2.8 pollution;

2.9 greenhouse gas emissions;

2.10 contamination; and

2.11 social surroundings.

These features should be shown on the site plan, where appropriate.

For all information, please indicate:

(a) the source of the information; and

(b) the currency of the information.

### 2.1 Flora and Vegetation

2.1.1 Do you propose to clear any native flora and vegetation as a part of this proposal?

[A proposal to clear native vegetation may require a clearing permit under Part V of the EP Act (Environmental Protection (Clearing of Native Vegetation) Regulations 2004)]. Please contact the Department of Environment and Conservation (DEC) for more information.

(please tick) ☒ Yes **If yes**, complete the rest of this section.

☐ No **If no**, go to the next section

2.1.2 How much vegetation are you proposing to clear (in hectares)?

The Proposal will require clearing of approximately 3,220 hectares (ha).

This proposed clearing is comprised of the following components: clearing for mining will be increased by 920 ha, from 2,260 ha to 3,180 ha; clearing for waste dumps will be increased by approximately 1,853 ha, from 1,407 ha to 3,260 ha; and clearing for infrastructure will be increased by 450 ha, from 1,000 ha to 1,450 ha.

2.1.3 Have you submitted an application to clear native vegetation to the DEC (unless you are exempt from such a requirement)?

☐ Yes ☒ No **If yes**, on what date and to which office was the application submitted of the DEC?

The clearing required for this Proposal is the subject of this application.

2.1.4 Are you aware of any recent flora surveys carried out over the area to be disturbed by this proposal?

☒ Yes ☐ No **If yes**, please attach a copy of any related survey reports and provide the date and name of persons / companies involved in the survey(s).

**If no**, please do not arrange to have any biological surveys conducted prior to consulting with the DEC.

Refer to Section 5 of the Environmental Review Document.

2.1.5 Has a search of DEC records for known occurrences of rare or priority flora or threatened ecological communities been conducted for the site?

☒ Yes ☐ No If you are proposing to clear native vegetation for any part of your proposal, a search of DEC records of known occurrences of rare or priority flora and threatened ecological communities will be required. Please contact DEC for more information.

A search of Department of Parks and Wildlife (DPaW) records was undertaken as part of the vegetation and flora assessment undertaken by *ecologia*.

2.1.6 Are there any known occurrences of rare or priority flora or threatened ecological communities on the site?

☒ Yes ☐ No **If yes**, please indicate which species or communities are involved and provide copies of any correspondence with DEC regarding these matters.

The Priority 1; West Angelas Cracking-Clay Priority Ecological Community (**PEC**) occurs extensively within the area. This community is defined as 'open tussock grasslands of *Astrebla pectinata*, *A. elymoides*, *Aristida latifolia* in combination with *Astrebla squarrosa* and low scattered shrubs of *Sida fibulifera*, on basalt derived cracking-clay loam depressions and flowlines'. Threats to this community include; clearing for further mining expansion and future infrastructure development, weed invasion and changes in fire regimes.

The West Angelas Cracking Clay PEC is not proposed to be detrimentally impacted by the Proposal.

Nine Priority Flora records are considered to be of relevance to the Proposal:

- *Aristida jerichoensis* var. *subspinulifera* (Priority (**P**) 1);
- *Brachyscome* sp. Wanna Munna Flats (S. van Leeuwen 4662) (P1);
- *Brunonia* sp. long hairs (D.E. Symon 2440) (P1);
- *Aristida lazaridis* (P2);
- *Indigofera gilesii* subsp. *gilesii* (P3);
- *Themeda* sp. Hamersley Station (M.E. Trudgen 11431) (P3);
- *Triodia* sp. Mt Ella (M.E. Trudgen 12739) (P3);
- *Rhagodia* sp. Hamersley (M. Trudgen 17794) (P3); and
- *Goodenia nuda* (P4).

Refer to Section 5 of the Environmental Review Document.

2.1.7 If located within the Perth Metropolitan Region, is the proposed development within or adjacent to a listed Bush Forever Site? (You will need to contact the Bush Forever Office, at the Department for Planning and Infrastructure)

☐ Yes ☐ No **If yes**, please indicate which Bush Forever Site is affected (site number and name of site where appropriate).

Not applicable.

2.1.8 What is the condition of the vegetation at the site?

West Angelas is not located within a pastoral lease and, as a result, is not actively grazed. Subsequently, the vegetation condition was assessed to be in very good to excellent condition despite evidence of weed invasion.

Refer to Section 5 of the Environmental Review Document.

## 2.2 Fauna

2.2.1 Do you expect that any fauna or fauna habitat will be impacted by the proposal?

(please tick) ☒ Yes **If yes**, complete the rest of this section.

☐ No **If no**, go to the next section.

2.2.2 Describe the nature and extent of the expected impact.

The Proposal will result in the clearing of up to 3,220 ha of potential fauna habitat, therefore habitat loss is likely to be the biggest threat to fauna, including several conservation significant fauna species (namely: Fork-tailed Swift, the Western Pebble-mound Mouse, the Short-tailed Mouse, the Ghost Bat, the Bush Stone-curlew and the Australian Bustard).

2.2.3 Are you aware of any recent fauna surveys carried out over the area to be disturbed by this proposal?

☒ Yes ☐ No **If yes**, please attach a copy of any related survey reports and provide the date and name of persons / companies involved in the survey(s).

**If no**, please do not arrange to have any biological surveys conducted prior to consulting with the DEC.

Refer to Section 6 of the Environmental Review Document.

2.2.4 Has a search of DEC records for known occurrences of Specially Protected (threatened) fauna been conducted for the site?

☒ Yes ☐ No (please tick)

A search of DPaW records was undertaken as part of the terrestrial fauna assessment undertaken by *ecologia*.

2.2.5 Are there any known occurrences of Specially Protected (threatened) fauna on the site?

☒ Yes ☐ No **If yes**, please indicate which species or communities are involved and provide copies of any correspondence with DEC regarding these matters.

Six conservation significant species recorded or assessed as having a high likelihood of occurrence are considered to be of relevance to the Proposal:

- Fork-tailed Swift, *Apus pacificus* (EPBC M, WC Act S3);
- Western Pebble-mound Mouse, *Pseudomys chapmani* (DPaW P4);
- Short-tailed Mouse, *Leggadina lakedownensis* (DPaW P4);
- Ghost Bat, *Macroderma gigas* (DPaW P4);
- Bush Stone-curlew, *Burhinus grallarius* (DPaW P4); and
- Australian Bustard, *Ardeotis australis* (DPaW P4).

The presence of the Ghost Bat represents the most significant faunal finding. Populations of this species are known from a series of roost caves in the region including the potential maternity cave; AA1 near Deposit F.

Refer to Section 6 of the Environmental Review Document.

### 2.3 Rivers, Creeks, Wetlands and Estuaries

2.3.1 Will the development occur within 200 metres of a river, creek, wetland or estuary?

(please tick) ☒ Yes **If yes**, complete the rest of this section.

☐ No **If no**, go to the next section.

2.3.2 Will the development result in the clearing of vegetation within the 200 metre zone?

☐ Yes ☒ No **If yes**, please describe the extent of the expected impact.

2.3.3 Will the development result in the filling or excavation of a river, creek, wetland or estuary?

☒ Yes ☐ No **If yes**, please describe the extent of the expected impact.

Deposit F is located within the same valley as an ephemeral unnamed tributary, hereafter referred to as central creek.

Central creek will be intercepted immediately upstream of Deposit F.

2.3.4 Will the development result in the impoundment of a river, creek, wetland or estuary?

☒ Yes ☐ No **If yes**, please describe the extent of the expected impact.

Deposit F, Pit F2 naturally intercepts central creek. A 2% AEP capacity diversion channel is proposed to divert the creek upstream of the F2 pit eastwards across the catchment divide into the adjacent Weeli Wolli catchment. No viable alternative option exists to continue the flow of this creek within its natural catchment.

Refer to Section 7 of the Environmental Review Document.

2.3.5 Will the development result in draining to a river, creek, wetland or estuary?

☐ Yes ☒ No **If yes**, please describe the extent of the expected impact.

2.3.6 Are you aware if the proposal will impact on a river, creek, wetland or estuary (or its buffer) within one of the following categories? (please tick)

| | | | |
|---|---|---|---|
| Conservation Category Wetland | ☐ Yes | ✓ No | ☐ Unsure |
| Environmental Protection (South West Agricultural Zone Wetlands) Policy 1998 | ☐ Yes | ✓ No | ☐ Unsure |
| Perth's Bush Forever site | ☐ Yes | ✓ No | ☐ Unsure |
| Environmental Protection (Swan & Canning Rivers) Policy 1998 | ☐ Yes | ✓ No | ☐ Unsure |
| The management area as defined in s4(1) of the *Swan River Trust Act 1988* | ☐ Yes | ✓ No | ☐ Unsure |
| Which is subject to an international agreement, because of the importance of the wetland for waterbirds and waterbird habitats (e.g. Ramsar, JAMBA, CAMBA) | ☐ Yes | ✓ No | ☐ Unsure |

## 2.4 Significant Areas and/ or Land Features

2.4.1 Is the proposed development located within or adjacent to an existing or proposed National Park or Nature Reserve?

☐ Yes ☒ No **If yes**, please provide details.

The Proposal is located approximately 20 km from the nearest boundary of the Karijini National Park.

2.4.2 Are you aware of any Environmentally Sensitive Areas (as declared by the Minister under section 51B of the EP Act) that will be impacted by the proposed development?

☐ Yes ☒ No **If yes**, please provide details.

2.4.3 Are you aware of any significant natural land features (e.g. caves, ranges etc) that will be impacted by the proposed development?

☐ Yes ☒ No **If yes**, please provide details.

## 2.5 Coastal Zone Areas (Coastal Dunes and Beaches)

2.5.1 Will the development occur within 300metres of a coastal area?

(please tick) ☐ Yes **If yes**, complete the rest of this section.

☒ No **If no**, go to the next section.

2.5.2 What is the expected setback of the development from the high tide level and from the primary dune?

2.5.3 Will the development impact on coastal areas with significant landforms including beach ridge plain, cuspate headland, coastal dunes or karst?

☐ Yes ☐ No **If yes**, please describe the extent of the expected impact.

2.5.4 Is the development likely to impact on mangroves?

☐ Yes ☐ No **If yes**, please describe the extent of the expected impact.

## 2.6 Marine Areas and Biota

2.6.1 Is the development likely to impact on an area of sensitive benthic communities, such as seagrasses, coral reefs or mangroves?

☐ Yes ☒ No **If yes**, please describe the extent of the expected impact.

2.6.2 Is the development likely to impact on marine conservation reserves or areas recommended for reservation (as described in *A Representative Marine Reserve System for Western Australia*, CALM, 1994)?

☐ Yes ☒ No **If yes**, please describe the extent of the expected impact.

2.6.3 Is the development likely to impact on marine areas used extensively for recreation or for commercial fishing activities?

☐ Yes ☒ No **If yes**, please describe the extent of the expected impact, and provide any written advice from relevant agencies (e.g. Fisheries WA).

## 2.7 Water Supply and Drainage Catchments

2.7.1 Are you in a proclaimed or proposed groundwater or surface water protection area?

(You may need to contact the Department of Water (DoW) for more information on the requirements for your location, including the requirement for licences for water abstraction. Also, refer to the DoW website)

☒ Yes ☐ No **If yes**, please describe what category of area.

The Proposal is located within the Pilbara Groundwater Area proclaimed under the *Rights in Water and Irrigation Act 1914*.

2.7.2 Are you in an existing or proposed Underground Water Supply and Pollution Control area?

(You may need to contact the DoW for more information on the requirements for your location, including the requirement for licences for water abstraction. Also, refer to the DoW website)

☐ Yes ☒ No **If yes**, please describe what category of area.

2.7.3 Are you in a Public Drinking Water Supply Area (PDWSA)?

(You may need to contact the DoW for more information or refer to the DoW website. A proposal to clear vegetation within a PDWSA requires approval from DoW.)

☐ Yes ☒ No **If yes**, please describe what category of area.

2.7.4 Is there sufficient water available for the proposal?

(Please consult with the DoW as to whether approvals are required to source water as you propose. Where necessary, please provide a letter of intent from the DoW)

☒ Yes ☐ No (please tick)

2.7.5 Will the proposal require drainage of the land?

☐ Yes ☒ No **If yes**, how is the site to be drained and will the drainage be connected to an existing Local Authority or Water Corporation drainage system? Please provide details.

2.7.6 Is there a water requirement for the construction and/ or operation of this proposal?

(please tick) ☒ Yes **If yes**, complete the rest of this section.

☐ No **If no**, go to the next section.

2.7.7 What is the water requirement for the construction and operation of this proposal, in kilolitres per year?

West Angelas is considered to be a water neutral (to small deficit) site in terms of water balance; operational water demand is roughly equivalent to dewatering requirements. While the site as a whole is water neutral, the water management of each deposit is different with some in deficit and others in surplus. Water sources are integrated to ensure continuity of supply across West Angelas. This integrated water management strategy will continue to be implemented to address water supply and demand requirements for the Revised Proposal.

Refer to Section 9 of the Environmental Review Document.

2.7.8 What is the proposed source of water for the proposal? (e.g. dam, bore, surface water etc.)

Dewatering water is used on-site in the first instance to supply water for operational purposes (processing and dust suppression).

The Turee Creek B Borefield is used to provide potable water to the mine and camp facilities and, when required, water for processing purposes and dust suppression.

## 2.8 Pollution

2.8.1 Is there likely to be any discharge of pollutants from this development, such as noise, vibration, gaseous emissions, dust, liquid effluent, solid waste or other pollutants?

(please tick) ☒ Yes **If yes**, complete the rest of this section.

☐ No **If no**, go to the next section.

2.8.2 Is the proposal a prescribed premise, under the Environmental Protection Regulations 1987?

(Refer to the EPA's *General Guide for Referral of Proposals to the EPA under section 38(1) of the EP Act 1986* for more information)

☒ Yes ☐ No **If yes**, please describe what category of prescribed premise.

The Proposal is a Prescribed Premise 'by association' since it is covered by the existing West Angelas Operating Licence L7774/2000. The licence allows Category 5, 6, 63, 64, 73 and 85 activities at West Angelas.

2.8.3 Will the proposal result in gaseous emissions to air?

☒ Yes ☐ No **If yes**, please briefly describe.

The Proposal will generate Greenhouse Gas (GHG) emissions.

2.8.4 Have you done any modelling or analysis to demonstrate that air quality standards will be met, including consideration of cumulative impacts from other emission sources?

☐ Yes ☒ No **If yes**, please briefly describe.

No modelling of projected emissions was undertaken as emissions generated by the Proposal are not expected to be greater than or different to those from existing operations.

Emissions have been, and will continue to be, managed under the existing operating licence, the *Clean Energy Act 2011* (Cwth) and the *National Greenhouse and Energy Reporting Act 2007* (Cwth).

2.8.5 Will the proposal result in liquid effluent discharge?

☐ Yes ☒ No **If yes**, please briefly describe the nature, concentrations and receiving environment.

2.8.6 If there is likely to be discharges to a watercourse or marine environment, has any analysis been done to demonstrate that the State Water Quality Management Strategy or other appropriate standards will be able to be met?

☐ Yes ☒ No **If yes**, please describe.

2.8.7 Will the proposal produce or result in solid wastes?

☒ Yes ☐ No **If yes**, please briefly describe the nature, concentrations and disposal location/ method.

Waste rock will be transported by haul trucks to external waste dumps according to the material categorisation. Where practicable, waste may also be used in progressive backfilling of the pits to assist in achieving closure objectives for the site.

Refer to Section 8 of the Environmental Review Document.

2.8.8 Will the proposal result in significant off-site noise emissions?

☐ Yes ☒ No **If yes**, please briefly describe.

Noise emissions are not expected to be significantly greater than or different to those of existing operations.

2.8.9 Will the development be subject to the Environmental Protection (Noise) Regulations 1997?

☒ Yes ☐ No **If yes**, has any analysis been carried out to demonstrate that the proposal will comply with the Regulations?

Please attach the analysis.

Noise emissions will be managed under the Environmental Protection (Noise) Regulations 1997. However, previous Noise Assessments have shown that noise levels at the only sensitive receptor, the village, will not exceed Environmental Protection (Noise) Regulation thresholds.

2.8.10 Does the proposal have the potential to generate off-site, air quality impacts, dust, odour or another pollutant that may affect the amenity of residents and other "sensitive premises" such as schools and hospitals (proposals in this category may include intensive agriculture, aquaculture, marinas, mines and quarries etc.)?

☐ Yes ☒ No **If yes**, please describe and provide the distance to residences and other "sensitive premises".

The location of West Angelas is very remote, with no neighbouring mining or pastoral activities. The nearest town, Newman, is located approximately 130 km south-east of West Angelas. Therefore, impacts on sensitive receptors from nuisance dust, noise or other air quality impacts are expected to be limited.

2.8.11 If the proposal has a residential component or involves "sensitive premises", is it located near a land use that may discharge a pollutant?

☐ Yes ☐ No ☒ Not Applicable

**If yes**, please describe and provide the distance to the potential pollution source

## 2.9 Greenhouse Gas Emissions

2.9.1 Is this proposal likely to result in substantial greenhouse gas emissions (greater than 100 000 tonnes per annum of carbon dioxide equivalent emissions)?

☐ Yes ☒ No **If yes**, please provide an estimate of the annual gross emissions in absolute and in carbon dioxide equivalent figures.

West Angelas is seen as a relatively small emitter of GHG.

2.9.2 Further, if yes, please describe proposed measures to minimise emissions, and any sink enhancement actions proposed to offset emissions.

## 2.10 Contamination

2.10.1 Has the property on which the proposal is to be located been used in the past for activities which may have caused soil or groundwater contamination?

☒ Yes ☐ No ☐ Unsure **If yes**, please describe.

Deposits A west and F will be developed as satellite deposits to the existing West Angelas mining operations.

2.10.2 Has any assessment been done for soil or groundwater contamination on the site?

☒ Yes ☐ No **If yes**, please describe.

Groundwater sampling and analysis of water quality indicates that the groundwater is of good quality.

Refer to Section 9 of the Environmental Review Document.

2.10.3 Has the site been registered as a contaminated site under the *Contaminated Sites Act 2003*? (on finalisation of the CS Regulations and proclamation of the CS Act)

☐ Yes ☒ No **If yes**, please describe.

## 2.11 Social Surroundings

2.11.1 Is the proposal on a property which contains or is near a site of Aboriginal ethnographic or archaeological significance that may be disturbed?

☒ Yes ☐ No ☐ Unsure **If yes**, please describe.

Archaeological and ethnographic surveys have been undertaken over the majority of the Proposal area. To date no ethnographic sites have been identified. A number of heritage sites have been identified at both Deposits A west and F.

At Deposit A west the majority of the heritage sites include artefact scatters. Based on the current design for Deposit A west, three artefact scatters will be impacted. Section 18 consent will need to be sought for impact to these sites.

At Deposit F the sites identified include rock shelters, scarred trees and artefact scatters. A significant rock shelter containing rock art is located approximately 500m to the north of pit F2.

Based on the current design for Deposit F, one artefact scatter will be directly impacted in pit F2. Three rock shelters within immediate proximity of pit F1 may be affected by indirect impacts as a result of blasting. Additionally, a rock shelter and scarred tree located within vicinity of pit F2 may also be affected by indirect impacts. Section 18 consent for these sites will need to be sought and the rock shelters may require archaeological excavation.

Refer to Section 9 of the Environmental Review Document.

2.11.2 Is the proposal on a property which contains or is near a site of high public interest (e.g. a major recreation area or natural scenic feature)?

☐ Yes ☒ No **If yes**, please describe.

The Proposal is an extension to an existing, very remote mining operation, located within an area where the dominant land uses are pastoral and mining.

There are no significant features that warrant public interest.

2.11.3 Will the proposal result in or require substantial transport of goods, which may affect the amenity of the local area?

☐ Yes ☒ No **If yes**, please describe.

## 3. PROPOSED MANAGEMENT

### 3.1 Principles of Environmental Protection

3.1.1 Have you considered how your project gives attention to the following Principles, as set out in section 4A of the EP Act? (For information on the Principles of Environmental Protection, please see EPA Position Statement No. 7, available on the EPA website)

1. The precautionary principle. ☒ Yes ☐ No
2. The principle of intergenerational equity. ☒ Yes ☐ No
3. The principle of the conservation of biological diversity and ecological integrity. ☒ Yes ☐ No
4. Principles relating to improved valuation, pricing and incentive mechanisms. ☒ Yes ☐ No
5. The principle of waste minimisation. ☒ Yes ☐ No

Refer to Section 13 of the Environmental Review Document

3.1.2 Is the proposal consistent with the EPA's Environmental Protection Bulletins/Position Statements and Environmental Assessment Guidelines/Guidance Statements (available on the EPA website)?

☒ Yes ☐ No

### 3.2 Consultation

3.2.1 Has public consultation taken place (such as with other government agencies, community groups or neighbours), or is it intended that consultation shall take place?

☒ Yes ☐ No **If yes**, please list those consulted and attach comments or summarise response on a separate sheet.

Refer to Section 3 of the Environmental Review Document.

Rio Tinto

# West Angelas – Revised Proposal

# Deposit A west and Deposit F

## Environmental Review Document

Robe River Mining Co. Pty. Ltd.

152 – 158 St Georges Terrace, Perth

GPO Box A42, Perth, WA 6837

December 2014

Final

**Disclaimer and Limitation**

This report has been prepared by Rio Tinto Iron Ore (Rio Tinto), on behalf of Robe River Mining Co. Pty. Ltd., specifically for the West Angelas Iron Ore Project. Neither the report nor its contents may be referred to without the express approval of Rio Tinto, unless the report has been released for referral and assessment of proposals.

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|---|---|---|---|---|---|
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# 1 INTRODUCTION

The West Angelas Iron Ore Mine (**West Angelas Project**) is located approximately 130 kilometres (**km**) northwest of Newman in the Pilbara region of Western Australia (Figure 1-1). Robe River Mining Co. Pty. Ltd. (hereafter **Robe**) is seeking approval to mine iron ore from above and below the water table at West Angelas Deposits A west and F (this **Proposal**), as satellite deposits to the existing West Angelas mining operations. The Referral Form for this Revised Proposal is provided in **Appendix 1**.

## 1.1 PROPONENT DETAILS

The Proponent for this Proposal is Robe River Mining Co. Pty. Ltd.

ABN: 71 008 694 246

GPO Box A42

Perth WA 6837

Robe (a wholly owned subsidiary of Rio Tinto) is the authorised manager of the West Angelas Iron Ore Mine on behalf of the Robe River Joint Venture Participants.

The contact person for this Proposal is:

Carly Nixon

Rio Tinto: Environmental Approvals Specialist

T: +61 (08) 6213 1297

carly.nixon@riotinto.com

## 1.2 EXISTING OPERATIONS

The West Angelas Project, which included Deposits A and B, was referred to the Environmental Protection Authority (**EPA**) under Part IV of the *Environmental Protection Act 1986* (**EP Act**) in May 1997 and was assessed at the level of Environmental Review and Management Program (**ERMP**). The ERMP was submitted to the EPA for assessment in March 1998. The EPA published its Report and Recommendations (Bulletin 924) on 30 January 1999 and the Minister for the Environment approved implementation of the West Angelas Project, subject to the conditions of Ministerial Statement 514 (**MS 514**), on 28 June 1999.

Ministerial Statement 970 (**MS 970**), which completely supersedes MS 514 and includes Deposit E, was approved on 11 June 2014. A copy of MS 970 is provided in **Appendix 2**.

The West Angelas Project, as implemented, consists of:

- Open cut mining of iron ore from above and below the water table (**AWT** and **BWT**) by conventional drill, blast, load and haul techniques. Three deposits have been approved for mining (Deposits A, B and E). Production commenced in 2001 at Deposit A and in 2011 at Deposit E. Mining is scheduled to commence at Deposit B in 2015.
- Ore processing in central processing facilities at a current rate of approximately 35 Million tonnes per annum (**Mtpa**).
- Surface waste dumps which will be used in progressive backfilling of the mine pits as far as practicable.

- A mine dewatering borefield which dewaters the ore bodies to allow mining BWT. Dewatering water is used on-site in the first instance to supply water for operational purposes (processing and dust suppression).
- The Turee Creek B Borefield, located approximately 30 km west of the mine site, which is used to provide potable water to the mine and camp facilities and, when required, water for processing purposes and dust suppression.
- An accommodation village which is located approximately 9 km west of the mine site.
- A mine access road which is approximately 35 km long and links the mine site with the Great Northern Highway.
- A railway network which transports processed ore approximately 413 km to port facilities located at Cape Lambert and Dampier.

A summary of the Key Characteristics of the West Angelas Project (from MS 970) is provided below in Table 1-1 and Table 1-2.

**Table 1-1: West Angelas Project Summary (MS 970)**

| | |
|---|---|
| **Proposal title** | West Angelas Iron Ore Project |
| **Proponent name** | Robe River Mining Co. Pty. Ltd. |
| **Short description** | Development and operation of an open-cut iron ore mine and associated infrastructure at the West Angelas Iron Ore Mine, 130 kilometres west of Newman in the Pilbara region (Figure 1). Iron ore is to be mined from above and below the water table in Deposits A, B and E.<br>The mining operations are supplied with water from the mine dewatering bores and water from the Turee Creek B Borefield, located approximately 30 kilometres west of the mine site.<br>Railway infrastructure from West Angelas to the port facilities at Cape Lambert. |

**Table 1-2: Location and Extent of Physical and Operational Elements (MS 970)**

| Element | Location | Authorised Extent |
|---|---|---|
| Mining Area (Deposits A, B and E) | Figure 2 (MS 970) | Clearing of no more than 2,260 hectares (**ha**) within a 19,853 ha development envelope. |
| Waste dumps | Figure 2 (MS 970) | Clearing of no more than 1,407 ha within a 19,853 ha development envelope. |
| Associated infrastructure, access and accommodation | Figure 2 (MS 970) | Clearing of no more than 1,000 ha within a 19,853 ha development envelope. |

The current mine layout (as approved under MS 970) is shown in Figure 1-2.

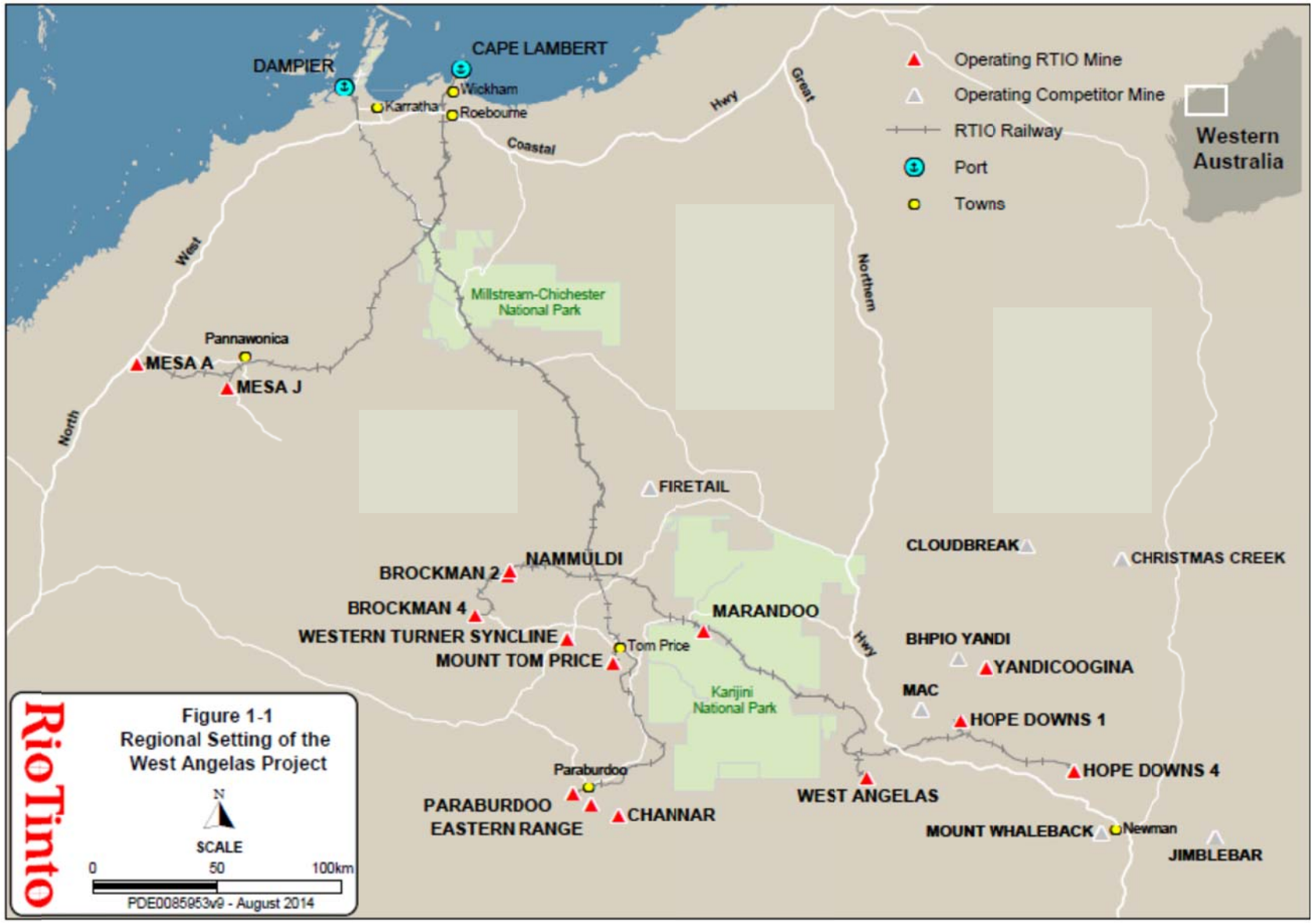



**Figure 1-1: Regional Setting of the West Angelas Project**

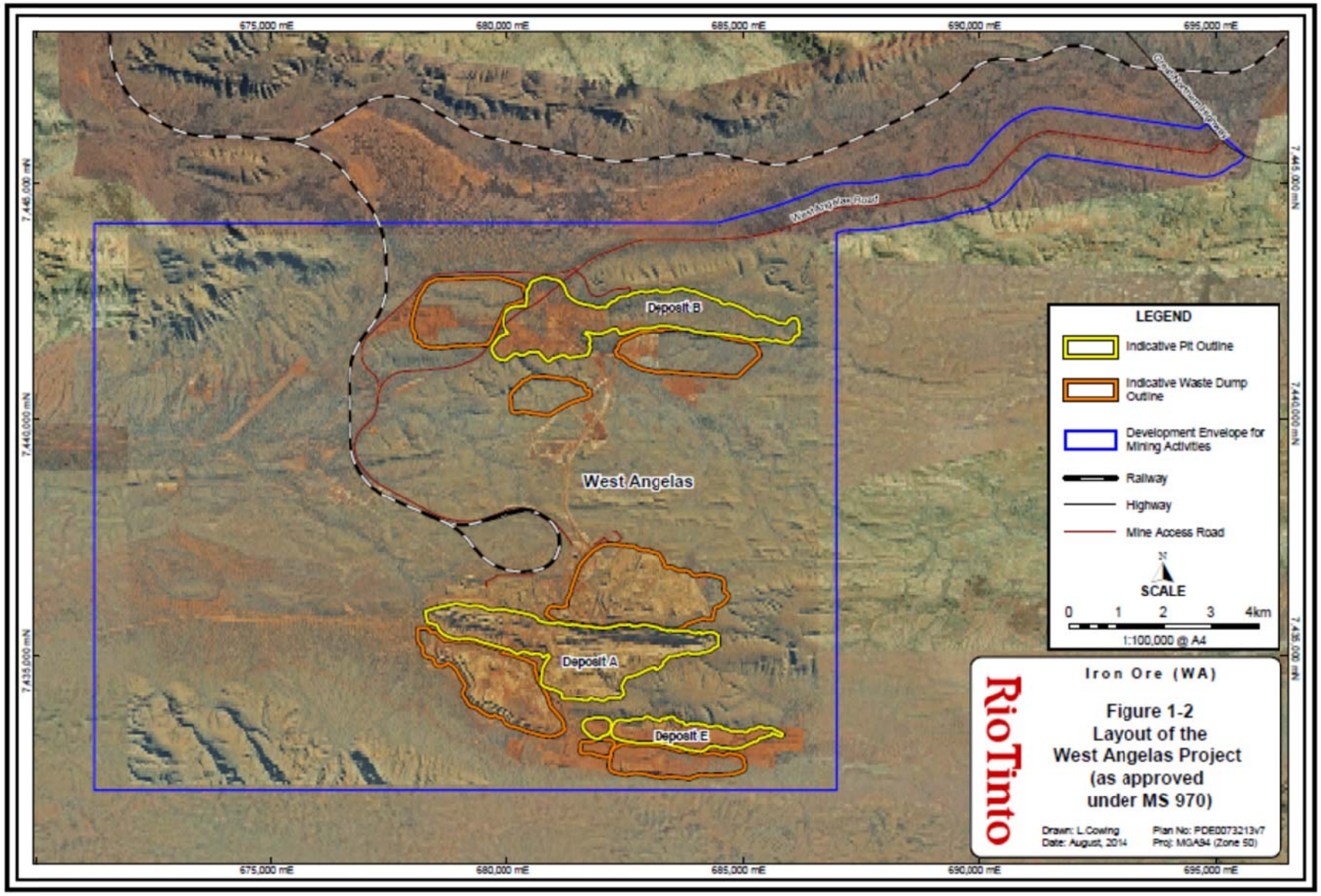



**Figure 1-2: Layout of the West Angelas Project (as approved under MS 970)**

## 1.3 TENURE

The West Angelas Project is located on Mineral Lease 248SA (**AML248SA**) which was granted in 1976 under the *Iron Ore (Robe River) Agreement Act 1964*. The infrastructure associated with the West Angelas mining operations is located on a number of Miscellaneous Licences and General Purpose Leases that were granted under the *Mining Act 1978* (refer to Figure 1-3) as follows:

- General purpose leases 47/1235 and 47/1236;
- Miscellaneous Licence L47/409 issued for the West Angelas gas pipeline and power station; and
- Miscellaneous Licences L47/52, L47/53, L47/54, L47/60, L47/61, and L47/62 issued for the purposes of roads and power lines, the repeater station and road, pipeline and power lines.

The leases are held under the Robe River Joint Venture (**RRJV**) which is managed on behalf of the partners by Robe. The current tenure is appropriate for all current and proposed mining activities and mining related infrastructure.

## 1.4 NATIVE TITLE AND AGREEMENTS

The West Angelas Project lies within two native title claims (refer to Figure 1-3).

The Yinhawangka People are the native title claimants and traditional custodians of the majority of the land within the West Angelas Project area. Negotiations with Yinhawangka for land access concluded in late 2012, resulting in the execution of the Rio Tinto – Yinhawangka Claim Wide Participation Agreement on 31 January 2013 and the subsequent execution of an Indigenous Land Use Agreement (**ILUA**), which was registered with the National Native Title Tribunal (**NNTT**) on 5 July 2013.

The Ngarlawangga People are the native title claimants for a portion of the Deposit F area. The Rio Tinto – Ngarlawangga Northern Claim Area Participation Agreement was fully executed on 22 March 2011. Confirmation of registration of the Ngarlawangga People Rio Tinto ILUA was received from the NNTT on 6 March 2013.

The ILUAs commit the RRJV and the Yinhawangka and Ngarlawangga People to work together on country to manage and maintain the areas in which the RRJV operates. The ILUAs set clear guidelines for processes such as land access, tenure, heritage and environmental approvals, mining benefits payments and reporting and communication requirements. The ILUAs replaces historical agreements including all prior Binding Initial Agreements with Yinhawangka and Ngarlawangga group members.

The Yinhawangka and Ngarlawangga People have also opted-in to the regional framework deed (**RFD**). The RFD establishes a clear and binding framework for effective program and partnerships between the RRJV and relevant Pilbara Traditional Owner groups, across areas including employment and training, cultural heritage management, business development and contracting, life of mine planning, environmental management and cultural awareness training.

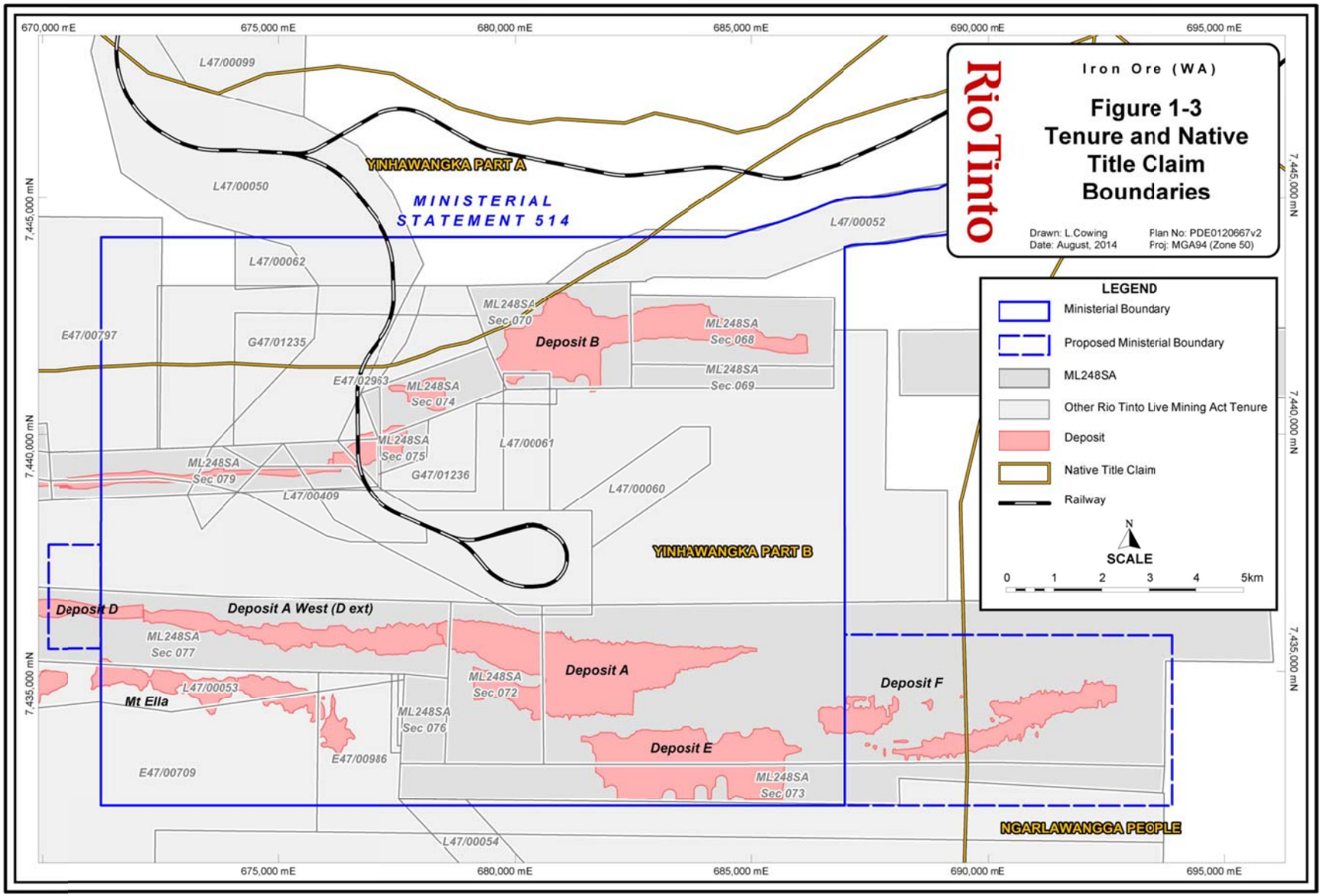



**Figure 1-3: Tenure and Native Title Claim boundaries**

## 1.5 LAND USE AND SOCIAL ENVIRONMENT

### 1.5.1 Historical Land Use

As of the early 1990s, much of the area in the vicinity of West Angelas Project was zoned as vacant Crown Land. The good condition of the vegetation at West Angelas has been attributed to the absence of historic cattle grazing, owing to the lack of water and palatable vegetation for cattle use. Pastoral activity in the region has historically been limited to grazing of cattle on Juna Downs Pastoral Station to the north (the most southern boundary of which is located approximately 20 km to the north) and Rocklea Pastoral Station approximately 75 km to the west.

### 1.5.2 Current land use

The Proposal is an extension to existing West Angelas operations. The location of the West Angelas Project is very remote with no neighbouring mining or pastoral activities, the dominant economic industries undertaken in the Pilbara.

**Mining**

Mining companies hold mining leases with iron ore resources adjacent to West Angelas Project, although no operations have been constructed in the immediate vicinity to date.

Mining Area C, an iron ore mine owned by BHP Billiton Iron Ore (**BHPBIO**) is located approximately 35 km north-north east of the West Angelas Project and is the closest development. Rio Tinto's Hope Downs mine is located approximately 45 km north east of the West Angelas Project. Five other iron ore mines are located within a 100 km radius of the West Angelas Project (refer to Figure 1-1).

**Communities**

Inland regions of the Pilbara are sparsely populated, with the largest inland towns (Tom Price, Paraburdoo and Newman) established specifically to support the mining industry. The nearest town, Newman, is located approximately 130 km south-east of West Angelas (Figure 1-1). West Angelas operates solely as a Fly-In Fly-Out (**FIFO**) operation. The workforce is housed on site, in a fully serviced accommodation facility. As a result, there is little direct social interaction between the workforce and surrounding local communities.

**Tourism**

National Parks are the major tourism focus in the central Pilbara region. The West Angelas Project is located approximately 20 km from the nearest boundary of the Karijini National Park.

The area contains no significant features that warrant attention from the tourism sector. There are no public roads in the vicinity to facilitate access for tourists; therefore tourism is very limited in, or adjacent to, the West Angelas Project.

# 2 PROPOSAL DESCRIPTION

This Proposal is seeking a revision to the existing West Angelas Project, with the following proposed changes:

- Development of additional Deposits A west and F (refer to Section 2.1).
- Additional clearing of approximately 3,220 ha (refer to Section 2.2).

The Revised Proposal is shown in Figure 2-1.

Note that the following terminology is used throughout this document:

- **West Angelas Project** - existing West Angelas Iron Ore operation, as approved under MS 970.
- **Proposal** – the changes proposed in this document.
- **Revised Proposal** – all components of the West Angelas Project that are currently authorised under MS 970, plus the changes that are described in this Proposal that will be authorised by a new Ministerial Statement, in the event of acceptance by the Minister of the Proposal.

## 2.1 THE PROPOSAL

Production commenced in 2001 at Deposit A and in 2011 at Deposit E. Deposit A provides the primary ore source with Deposit E supplementing the production to maintain the current production rate. Deposit B is the next major ore source with mining scheduled to commence in 2015. Production from all existing deposits will decline from 2016. An additional ore source is therefore required to sustain current production from the West Angelas Project. Deposits A west and F have been identified as the next to be developed in the conceptual long term development strategy.

Robe proposes to commence mining of Deposits A west and F in 2016. The key components of the Proposal are as follows:

### 2.1.1 Mining and Transport

The Proposal involves conventional open pit mining of iron ore from above and below the water table in Deposits A west and F, as satellite deposits to the existing West Angelas mining operations. Approximately 85 million tonnes (**Mt**) of ore is estimated to be mined from these deposits (approximately 30 Mt and 55 Mt from Deposits A west and F, respectively). Once mined, ore will be transported by haul trucks approximately 5 km and 12 km respectively to existing processing facilities at West Angelas.

A number of transport and processing options have been investigated for both deposits. The transport of ore by haul trucks to existing processing facilities is preferred for both deposits. Haul route options are shown on Figure 2-1.

### 2.1.2 Waste

Waste rock will be transported by haul trucks to external waste dumps according to the material categorisation. Where practicable, waste may also be used in progressive backfilling of the pits to assist in achieving closure objectives for the site.

The likelihood of encountering potentially acid-forming (**PAF**) materials (e.g. black shale material) is considered low for both deposits. Further discussion about PAF materials and a broader assessment of Acid and Metalliferous Drainage (**AMD**) risk is discussed in Section 9.

### 2.1.3 Surface Water Management

A number of surface water management options have been considered for both deposits. The preferred option for Deposit A west is a diversion channel to redirect flows from the local catchment westwards, thereby maintaining natural flows. A passive surface water management strategy is proposed for pits F1 and F3 at Deposit F, whereby local catchments will be allowed to naturally terminate in the pits. The preferred option for pit F2 at Deposit F is a diversion channel to redirect flows eastwards into the adjacent Weeli Wolli catchment. The management of surface water is discussed in Section 7.

### 2.1.4 Dewatering, Water Use and Disposal of Surplus Water

Approximately 6% of the Deposit A west resource and 1% of the Deposit F resource is below the water table. The Proposal therefore requires minimal dewatering ahead of mining to provide dry conditions for mining BWT.

West Angelas is considered to be a water neutral (to small deficit) site; whereby operational water demand is roughly equivalent to dewatering requirements. While the site as a whole is water neutral in terms of water balance, the water management of each deposit is different with some in deficit and others in surplus. Dewatering at Deposit A west is likely to meet demand with a small surplus available for use elsewhere while a water deficit is predicted for Deposit F; additional water sources are likely to be required to meet demand.

Groundwater abstraction (i.e. dewatering) is regulated by Department of Water (**DoW**) licensing and the *Rights in Water and Irrigation Act 1914* (**RIWI Act**). Any surplus water, exceeding the operational water demand will continue to be discharged to the environment. Discharge is regulated by Department of Environmental Regulation (**DER**) licensing. The management of groundwater is discussed in Section 9.

## 2.2 CLEARING

The Proposal will require clearing of approximately 3,220 ha in addition to that approved under MS 970. The Revised Proposal clearing will reflect the following components:

- clearing for mining will be increased by 920 ha, from 2,260 ha to 3,180 ha;
- clearing for waste dumps will be increased by 1,853 ha, from 1,407 ha to 3,260 ha; and
- clearing for infrastructure will be increased by 450 ha, from 1,000 ha to 1,450 ha.

A small portion of the additional clearing will be allocated to minor changes to the existing West Angelas Project to support ongoing operations.

The proposed additional clearing is not expected to impact on any areas or species of elevated conservation significance. The management of vegetation and flora, fauna and fauna habitats is discussed in Sections 5 and 6 respectively.

## 2.3 KEY CHARACTERISTICS OF THE REVISED PROPOSAL

This Proposal will be implemented as a revision of the existing West Angelas Project. Table 2-1 provides a summary of the Revised Proposal and Table 2-2 provide details on the proposed location and authorised extent of physical and operational elements of the Revised Proposal for inclusion in the proposed new Statement. The new or modified factors being assessed in this Proposal are highlighted to assist with identification.

The proposed changes are also included in the draft Ministerial Statement provided in Appendix 3. Robe proposes to maintain and adhere to the existing environmental conditions.

**Table 2-1: Summary of the Revised Proposal**

| | |
|---|---|
| **Proposal title** | West Angelas Iron Ore Project – **Revised Proposal** |
| **Proponent name** | Robe River Mining Co. Pty. Ltd. |
| **Short description** | Development and operation of an open-cut iron ore mine and associated infrastructure at the West Angelas Iron Ore Mine, 130 kilometres northwest of Newman in the Pilbara region (Figure 1). Iron ore is to be mined from above and below the water table in Deposits A, **A west**, B, E and **F**.<br>The mining operations are supplied with water from the mine dewatering bores and water from the Turee Creek B Borefield, located approximately 30 kilometres west of the mine site.<br>Surplus water, exceeding operational water demand is discharged to the environment.<br>Railway infrastructure from West Angelas to the port facilities at Cape Lambert. |

**Table 2-2: Location and Extent of Physical and Operational Elements of the Revised Proposal**

| Element | Location | Authorised Extent |
|---|---|---|
| Mining Area (Deposits A, **A west**, B, E and **F**) | Figure 2 | Clearing of no more than **3,180 hectares (ha)** within a **22,600 ha** development envelope.<br>*Clearing increased by 920 ha* |
| Waste dumps | Figure 2 | Clearing of no more than **3,260 ha** within a **22,600 ha** development envelope.<br>*Clearing increased by 1,853 ha* |
| Associated infrastructure, access and accommodation | Figure 2 | Clearing of no more than **1,450 ha** within a **22,600 ha** development envelope.<br>*Clearing increased by 450 ha* |

## 2.4 DEVELOPMENT ENVELOPE OF THE REVISED PROPOSAL

The EPA's Environmental Assessment Guideline No. 1 (**EAG1**) (EPA 2012b) allows for the clearing footprint of a proposal to be defined within a broader development envelope provided that appropriate biological surveys and an environmental impact assessment have been conducted for the area.

The current development envelope is 19,853 ha. The spatial extent of the existing development envelope is shown in Figure 2, Schedule 1 of MS 970 (Appendix 2). A portion of the proposed additional clearing falls within the existing MS 970 development envelope. However, the Proposal will require an extension of approximately 2,747 ha to the extent of the envelope for the development of Deposits A west and F. The spatial extent of the development envelope for the Revised Proposal is shown in Figure 2-1 and Figure 2, Schedule 1 of the Proposed MS (Appendix 3). This development envelope includes all elements of the existing Project approved under MS 970 as well as this Proposal.

The western extension of the development envelope is proposed to allow for the design of any elements of the Proposal to the north of the Deposit A west (e.g. haul roads, pipelines, power or other infrastructure) to preferentially avoid intersecting the West Angelas Cracking Clay Priority Ecological Community (**PEC**).

Biological surveys have been undertaken across the West Angelas region since 1979. The combined coverage of these surveys has enabled a detailed understanding of the existing vegetation and flora, fauna and fauna habitats in the region. Sections 5 and 6 describe the key biological surveys relevant to this Proposal.

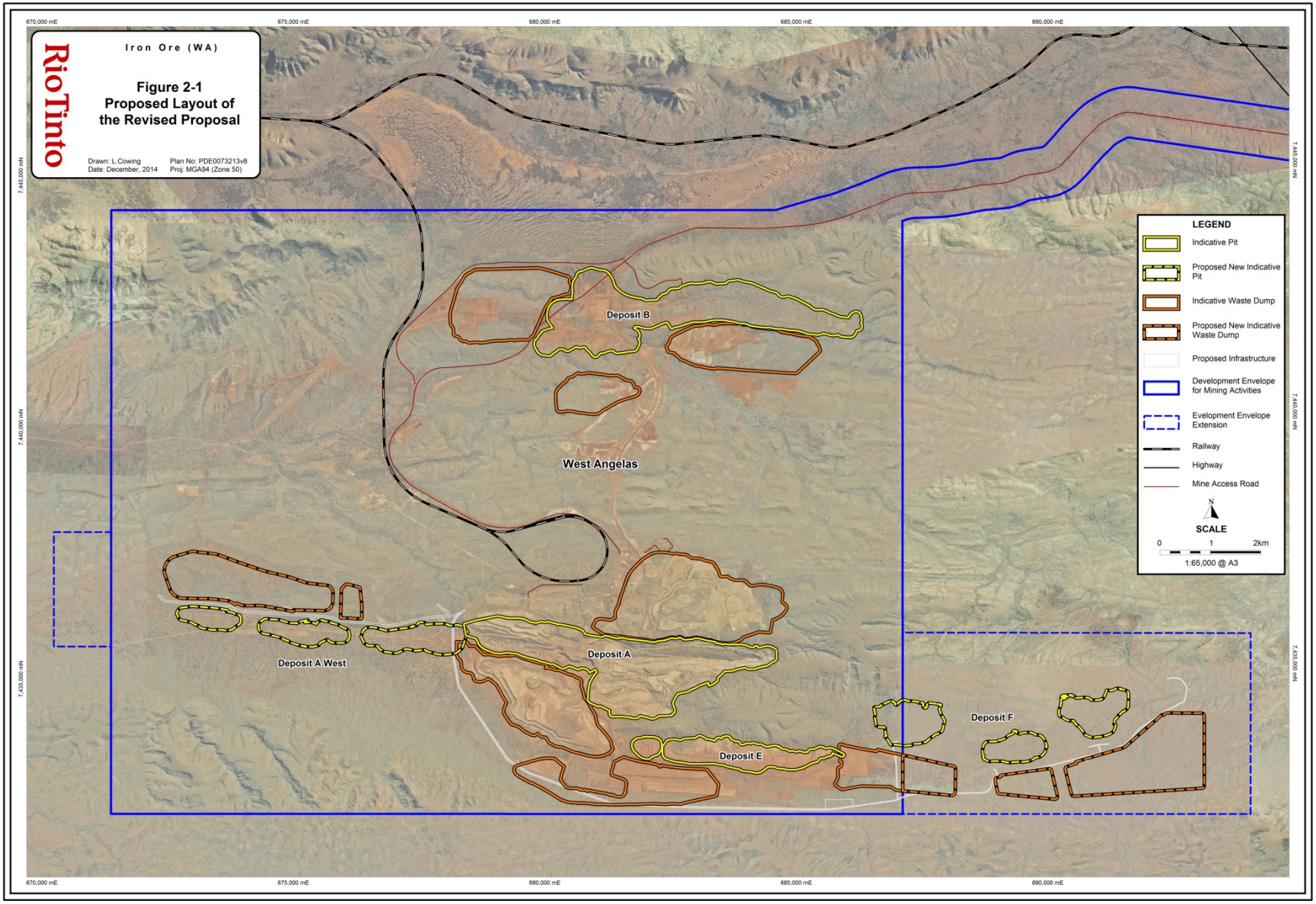



**Figure 2-1: Proposed Layout of the Revised Proposal**

# 3 STAKEHOLDER CONSULTATION

Identified key stakeholders for this Proposal include:

- Government agencies:
    - Office of the Environmental Protection Authority (**OEPA**);
    - Department of Parks and Wildlife (**Parks and Wildlife**);
    - Department of Environment and Regulation (**DER**);
    - Department of Water (**DoW**);
    - Department of Mines and Petroleum (**DMP**);
    - Department of State Development (**DSD**);
    - Department of Aboriginal Affairs (**DAA**); and
    - Shire of East Pilbara.
- Traditional Owners:
    - Yinhawangka Group; and
    - Ngarlawangga Group.

Stakeholder consultation undertaken to date, and Robe's response to issues raised, is detailed in Table 3-1. Robe will continue to consult with relevant stakeholders during the environmental approval process and during implementation of the Proposal.

**Table 3-1: Stakeholder Consultation Relevant to this Proposal**

| Date | Topics/Issues Raised | Proponent Response |
|---|---|---|
| **Office of the Environmental Protection Authority (OEPA)** | | |
| 23/05/2014 | The Proponent provided an update on the timing of the submission of the Deposit A west and F Revised Proposal at the Rio Tinto – OEPA monthly meeting. No issues or concerns were raised by OEPA. | |
| 25/08/2014 | The Proponent provided an update on the timing of the submission of the Deposit A west and F Revised Proposal Environmental Review document at the Rio Tinto – OEPA monthly meeting. No issues or concerns were raised by OEPA. | |
| 24/09/2014 | The Proponent provided an overview of the Proposal. OEPA advised that a Revised Proposal was appropriate.<br>OEPA requested a formal pre-referral meeting prior to the submission of the Referral and Environmental Review document. | The Proponent scheduled a pre-referral meeting with OEPA for 2 October 2014. |
| 2/10/2014 | The Proponent scheduled a pre-referral meeting with OEPA for 2 October 2014 to present an overview of the Proposal and discuss the approvals pathway.<br>The interaction between the Cracking Clay PEC and surface water flows in the area was discussed in some detail. OEPA were interested in understanding whether the Deposit A west waste dump could result in water quality issues for the Cracking Clay PEC.<br>OEPA also emphasised a focus on closure and rehabilitation. Given the recent update to the Ministerial Statement, OEPA advised that the exiting conditions were likely to be acceptable however; a revision to the Condition 9 of the Ministerial Statement was likely to be applied to address the requirement to submit revisions of the Closure Plan.<br>Based on the information provided by the Proponent, OEPA advised that the Proposal is likely to be assessed via an API Category A. To verify this level of assessment is appropriate, the OEPA requested that the Proponent provide a draft copy of the Environmental Review document to OEPA prior to formally referring the Proposal. | The Proponent advised that waste dumps are designed to be internally draining such that runoff to the Cracking Clay PEC is expected to be negligible. The proponent also committed to review the Deposit A west waste dump design to minimise the reduction in the local catchment area contributing to the Cracking Clay PEC.<br>Closure and rehabilitation are addressed in this document. The Proponent also has incorporated a proposed change to Condition 9 to address the requirement to submit revisions of the Closure Plan.<br>The Proponent will provide a draft copy of the Environmental Review document to OEPA.<br>The Proponent will continue to consult with OEPA throughout the environmental approvals process. |

| Date | Topics/Issues Raised | Proponent Response |
|---|---|---|
| 21/10/2014 | The Proponent met with OEPA on 21 October 2014 to discuss the OEPA review of the draft Environmental Review document.<br>OEPA requested that the Proponent provide additional evaluation of potential Short Range Endemic fauna and subterranean fauna. Specifically:<br>• how the proposed management would enable the EPA's objectives to be met with regards to Short Range Endemic fauna; and<br>• justification as to why subterranean fauna has not been identified as a key environmental factor<br>OEPA also requested additional evidence of consultation with DAA. | The Proponent provided additional evaluation of potential Short Range Endemic fauna and subterranean fauna in the final copy of the Environmental Review document (this document).<br>The Proponent also provided additional evidence of consult with the DAA in this table. |
| 25/11/2014 | The Proponent provided a revised copy of the draft Environmental Review document to the OEPA.<br>OEPA requested minor amendments to the final Environmental Review document. | The Proponent included the minor amendments requested by the OEPA in the final copy of the Environmental Review document (this document). |
| **Department of Parks and Wildlife (Parks and Wildlife)** | | |
| 30/09/2014 | The Proponent discussed the Proposal with Parks and Wildlife via a phone conversation on 30 September 2014.<br>Parks and Wildlife were interested in understanding the interaction between the Proposal and conservation significant areas and species (those protected under the *Wildlife Conservation Act 1950*). The Proponent discussed the presence of the Cracking Clay PEC, the known Ghost Bat roosting cave and Priority Flora species.<br>Based on the information provided by the Proponent, Parks and Wildlife did not require a formal pre-referral meeting. The Proponent will provide a copy of the Referral and Environmental Review document to Parks and Wildlife for their information and will meet with Parks and Wildlife to discuss any specific concerns on request. | The Proponent advised that the PEC is not expected to be detrimentally impacted by the Proposal.<br>The Proponent discussed the proposed 100 m exclusion zone and committed to the ongoing implementation of blast management to protect the known Ghost Bat roosting cave.<br>The Proponent also advised that some occurrences of Priority flora will be cleared however; the Proposal will preferentially avoid known locations of Priority flora as far as practicable.<br>The Proponent will continue to consult with Parks and Wildlife throughout the environmental approvals process. |
| **Department of Environment Regulation (DER)** | | |
| Ongoing | The Proponent will apply for relevant approvals and licences as required under Part V of the *Environmental Protection Act 1986*. | |

| Date | Topics/Issues Raised | Proponent Response |
|---|---|---|
| **Department of Water (DoW)** | | |
| 23/09/2014 | The Proponent scheduled a meeting with DoW for 23 September 2014 to present an overview of the Proposal and to discuss any concerns, specifically related to water.<br>The interaction between the Cracking Clay PEC and surface water flows in the area was discussed in some detail. DoW were interested in understanding the overland flow contribution to the Cracking Clay PEC. | The proponent presented an overview of 2D hydraulic modelling that has been undertaken to understand the interactions between the Cracking Clay PEC and patterns of surface water flow in the area and committed to provide further detail in this document.<br>The proponent also committed to review the Deposit A west waste dump design to minimise the reduction in the local catchment area contributing to the Cracking Clay PEC.<br>The Proponent will continue to consult with DoW throughout the environmental approvals process and will apply for relevant approvals and licences as required under the *Rights in Water and Irrigation Act 1914.* |
| **Department of Mines and Petroleum (DMP)** | | |
| 27/08/2014 | The Proponent requested guidance from DMP regarding stakeholder consultation for Proposals considered to be of API-A level of assessment. DMP indicated that it would be their preference for the Proponent to present an overview of the Proposal rather than providing a draft copy of the Environmental Review document and to discuss any specific concerns. | The Proponent committed to meet with DMP to provide an overview of the Proposal and discuss any specific concerns. |
| 2/10/2014 | The Proponent scheduled a meeting with DMP for 2 October 2014 to present an overview of the Proposal and to discuss any concerns, specifically related to closure.<br>Material types were discussed in some detail. DMP were interested in understanding the closure strategy given the generally highly erodible material present at West Angelas. The Proponent discussed backfill and capping strategies.<br>DMP also queried whether PAF materials would be encountered. The Proponent discussed the low risk of encountering PAF materials based on assessments completed.<br>The Proponent also discussed the proposed diversion of surface water flows. DMP were interested in the engineering of the diversion structures. Design has not been undertaken, the Proponent intends to commission engineering to design the diversion structures. | The Proponent committed to investigate opportunities to backfill.<br>The Proponent will continue to consult with DMP throughout the environmental approvals process. |

| Date | Topics/Issues Raised | Proponent Response |
|---|---|---|
| **Department of State Development (DSD)** | | |
| Ongoing | The Proponent provides updates on relevant projects at monthly meetings with DSD. No specific concerns have been raised to date with the Proposal. | The Proponent will continue consultation with DSD regarding any planned submissions for approval under the *Iron Ore (Robe River) Agreement Act 1964.* |
| **Department of Aboriginal Affairs (DAA)** | | |
| Ongoing | The Proponent's Heritage Team consider that they have a good working relationship with the DAA and provides ongoing updates on relevant Proposals and heritage matters at regular liaison meetings.<br>Given that heritage surveys are still being undertaken and therefore, that the number, type and significance of heritage sites which may be impacted by the Proposal are not yet known, there has been limited consultation with DAA specifically regarding the Proposal to date. Heritage surveys are scheduled to continue in late 2014 and early 2015. Once this work is complete, the Proponent will consult DAA on Proposal specific heritage matters.<br>Direct and indirect impacts to heritage sites will be avoided as far as practicable. The Proponent will seek section 18 (**s18**) consent under the *Aboriginal Heritage Act 1972* (**AHA**) to disturb any heritage sites that cannot be avoided. The Proponent will consult DAA at regular liaison meetings regarding any planned submissions for s18 consent in advance of submission. | The Proponent will continue regular liaison meetings with DAA and will discuss Proposal specific matters as required.<br>The Proponent will consult with DAA regarding any planned submissions for approval under s18 of the AHA to disturb any heritage sites that cannot be avoided. |
| **Shire of East Pilbara** | | |
| 24/09/2014 | The Proponent scheduled a meeting with the Shire of East Pilbara for 24 September 2014 to present an overview of the Proposal and to discuss any concerns. No significant concerns were raised. | The Proponent will continue liaising with the Shire of East Pilbara and will discuss Proposal specific matters as required. |

| Date | Topics/Issues Raised | Proponent Response |
|---|---|---|
| **Yinhawangka Traditional Owners** | | |
| 17/08/2006 | The Proponent informed the Yinhawangka Group of planned future development of Deposit F. It was discussed that there are no plans for significant dewatering of groundwater and that backfilling of the pits will be investigated.<br>The Proponent mentioned that environmental approvals process requires protection of the environment, minimising clearing of the vegetation, backfill and rehabilitation. | The Proponent committed to continue consultation with the Yinhawangka Group. |
| Ongoing | Issues relevant to the Yinhawangka Group are discussed at six monthly Local Implementation Committee (LIC) meetings, as agreed to in the Yinhawangka Claim Wide Participation Agreement. The first Yinhawangka LIC meeting was held on 14 March 2013.<br>This Proposal was raised at the Yinhawangka LIC meeting on 29 April 2014. No significant concerns have been raised however; the cumulative impact of surface water diversions has been identified as a key issue for ongoing discussion. The Yinhawangka Group have requested to be consulted regarding surface water management.<br>The next LIC meeting scheduled for 13 November 2014, the focus of these discussions will be Deposit E. The Proposal will be discussed again at the first LIC meeting for 2015, tentatively scheduled for early April. | The Proponent will continue with regular consultation with the Yinhawangka Group through the LIC meetings. |
| **Ngarlawangga Traditional Owners** | | |
| Ongoing | Issues relevant to the Ngarlawangga Group are discussed at six monthly Local Implementation Committee (LIC) meetings, as agreed to in the Ngarlawangga Northern Claim Area Participation Agreement. The first Ngarlawangga LIC meeting was held on 12 May 2013.<br>The Proposal will be raised at the next LIC meeting scheduled for 7 November 2014. | The Proponent will continue with regular consultation with the Ngarlawangga Group through the LIC meetings. |

# 4 ENVIRONMENTAL IMPACTS AND MANAGEMENT

## 4.1 ENVIRONMENTAL APPROVALS PROCESS

This Proposal is a revision to the existing West Angelas Project (MS 970).

This Environmental Review document has been provided to the OEPA to support the referral of the Revised Proposal and has been prepared in accordance with the EPA's Environmental Assessment Guidelines (**EAGs**): specifically Defining the Key Characteristics of a Proposal *Environmental Protection Act 1986* (**EAG 1**) (EPA 2012b), EAG for Environmental factors and objectives (**EAG 8**) (EPA 2013a) and EAG for Application of a significance framework in the environmental impact assessment process (**EAG 9**) (EPA 2013b).

The Referral Form for this Revised Proposal has been prepared in accordance with Section 38(1) of the EP Act and is provided in Appendix 1.

It is expected that upon approval of this Proposal, Ministerial Statement 970 will be superseded and that a new Ministerial Statement will be issued for the Revised Proposal. It is intended that the Revised Proposal will be managed in accordance with the existing legislative controls and the Environmental Management Program (**EMP**), which has been updated to include all components of the Revised Proposal (Appendix 7).

## 4.2 ASSESSMENT OF ENVIRONMENTAL FACTORS

The environmental factors and objectives adopted by the EPA are listed in EAG 8. Robe has identified and assessed the Key Environmental Factors that are relevant to this Revised Proposal, based on EAG 8 and EAG 9. The outcome of the assessment is shown in Figure 4-1.

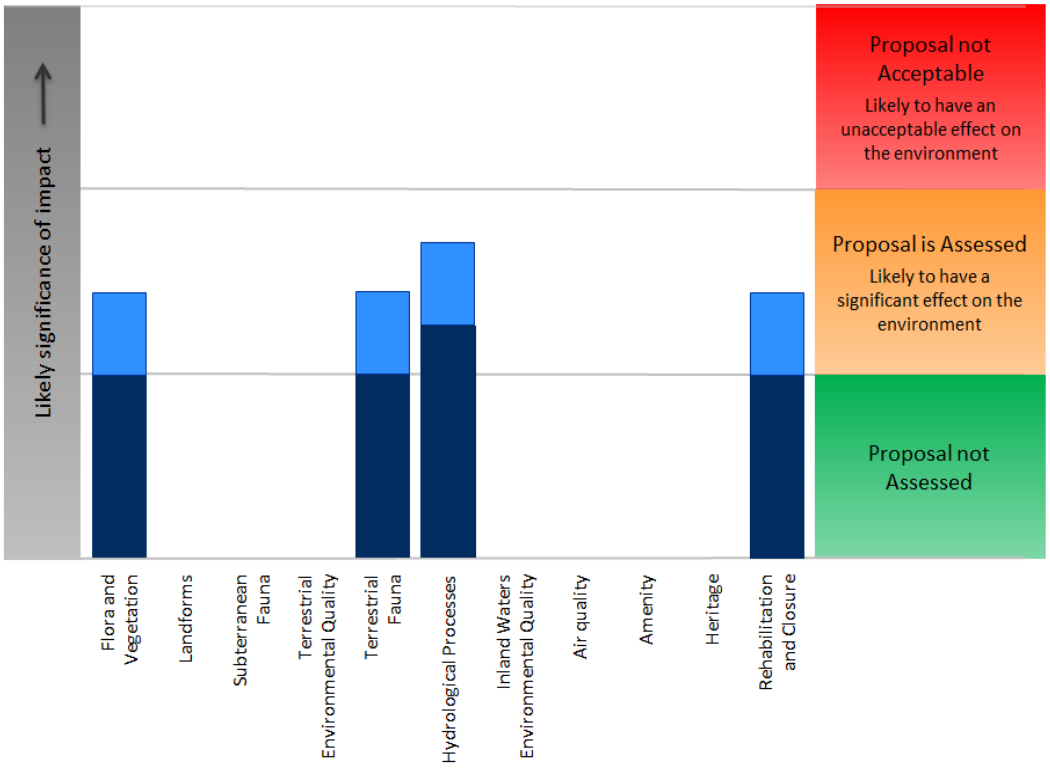



**Figure 4-1: Significance Framework for Environmental Factors for the Revised Proposal (from EAG 8 and EAG 9).**

The Key Environmental Factors relevant to this Revised Proposal are identified as follows:

- flora and vegetation (Section 5);
- terrestrial fauna (Section 6);
- hydrological processes (surface water) (Section 7); and
- rehabilitation and closure (Section 8).

The above assessment included consideration of existing legislative controls for each identified Key Environmental Factor (shown in Figure 4-1).

Robe considers that for the remaining environmental factors, the Revised Proposal will not result in any significant change in addition to, or different from, that originally assessed and approved under MS 970. Each of these factors has been addressed in Section 9.

As such, Robe has concluded that the Revised Proposal meets the EPA's Objectives and should be assessed at an Assessment on Proponent Information (**API**)-A level of assessment where the existing conditions of Ministerial Statement 970 are appropriate to continue managing the Proposal to meet the EPA's objectives.

### 4.3 ENVIRONMENTAL MANAGEMENT OVERVIEW

Rio Tinto has developed and refined environmental management objectives, systems and procedures over decades of operational mining experience in the Pilbara region that are successfully applied at multiple iron ore mine sites.

The key components of the environmental management approach that will continue to be implemented for the Revised Proposal include:

1. The Rio Tinto Iron Ore Group Health, Safety, Environment, Communities and Quality Policy (**HSECQ Policy**). The HSECQ Policy is the guiding document for environmental management and provides context and direction for continuous improvement.
2. Rio Tinto Iron Ore (WA) operates under an Environmental Management System (**EMS**), contained within the HSEQ Management System. The HSEQ Management System is a continuous improvement model covering:
    - systematic assessment of environmental risk and legal requirements; systems for training, operational control, communication, emergency response and corrective actions;
    - the development of objectives and targets for improvements; and
    - audits and review.
3. The existing conditions of Ministerial Statement 970, including but not limited to:
    - Condition 7 for Surface Water;
    - Condition 8 for Conservation Significant Communities and Species; and
    - Condition 9 for Rehabilitation and Closure.
4. The West Angelas Operations Environmental Management Program (**EMP**) prepared in November 2013 and approved by the Office of the EPA in June 2014.

5. Existing licences issued under Part V of the EP Act and the RiWI Act:
    - Operating Licence L7774/2000, issued under Part V of the EP Act for processing, dewatering, discharge, landfill and sewage treatment facility;
    - Operating Licence L7642/2000, issued under Part V of the EP Act for the village sewage treatment facility;
    - Groundwater Licence GWL98740, issued under the RiWI Act for abstraction of 5,000,000 kL from the for dewatering and water supply purposes; and
    - Groundwater Licence GWL103136, issued under the RiWI Act for abstraction of 3,102,500 kL from the Turee B Borefield for water supply purposes.
6. The Rio Tinto closure approach will continue to guide closure planning for the Revised Proposal. This approach governs:
    - commencement of planning for closure prior to project commencement;
    - the development and content of closure plans;
    - stakeholder consultation regarding closure;
    - financial provisioning for closure;
    - the review of closure plans; and
    - the development of Decommissioning Plans five years prior to scheduled closure.

Consideration of existing legislative controls for each of the key environmental factors relevant to this Proposal is shown in Figure 4-1.

### 4.4 PROPOSED ENVIRONMENTAL CONDITIONS

Robe proposes to maintain and adhere to the existing environmental conditions of MS970 (refer to Appendix 2) to address the key environmental aspects of the Revised Proposal. It is proposed that these environmental conditions be applied to the Revised Proposal (i.e. the existing West Angelas Project approved under Ministerial Statement 970 and this Proposal).

These environmental conditions do not duplicate other regulatory controls that are, or will be, applied under other existing legislation (refer to Section 10). A condition has not been imposed if the environmental factor is already adequately addressed by other environmental control instruments (i.e. the existing West Angelas Operations EMP).

# 5 VEGETATION AND FLORA

This Section describes the vegetation and flora that occur within the Proposal area and provides details regarding the potential impacts to conservation significant vegetation communities and flora species from 3,220 ha of additional clearing that forms part of this Proposal.

The EPA applies the following objective from EAG 8 in its assessment of proposals that may affect vegetation and flora:

> *To maintain representation, diversity, viability and ecological function at the species, population and community level.*

Table 5-3 describes how the Proposal meets the EPA's objectives in respect of vegetation and flora.

## 5.1 VEGETATION AND FLORA STUDIES

Vegetation and flora surveys have been undertaken across the West Angelas region since 1979, covering an area in excess of 61,600 ha. Table 5-1 summarises the key surveys relevant to this Proposal.

In addition, Robe has conducted a number of targeted searches for Declared Rare Flora (**DRF**) and Priority Flora in the area that provides a considerable reference for the distribution of these species.

The combined coverage of these surveys has enabled a detailed understanding of the existing vegetation and flora in the West Angelas region.

**Table 5-1: Summary of Supporting Studies**

| Report Title, Author and Year | Summary of Studies |
|---|---|
| *An ecological appreciation of the West Angelas environment, Western Australia 1979.*<br>Integrated Environmental Services (1978) | Survey of vegetation conducted in all seasons of the years 1978 and 1979 across West Angelas. The vegetation of the West Angelas region was described in 1979 as:<br>• *Triodia sp.* Hummock Grassland (on ridges, steep slopes and lower slopes);<br>• *Acacia aneura* Mulga Low Woodland (on valley floors);<br>• *Acacia kempeana* Low Scrub (on ridges and lower slopes);<br>• *Eucalyptus kinsmillii* Open Shrub Mallee (on ridges);<br>• *Callitris columellaris* Stands (on fire protected slopes and gorges); and<br>• Eucalyptus Fringing Woodland (riverine areas).<br>None of the vegetation was considered to be rare. |
| *A flora survey of Orebody A near West Angela Hill, with description of vegetation of flora collecting sites*<br>M. Trudgen (1995) | Collection of flora species conducted at Deposit A following good rainfall.<br>The vegetation of the West Angelas region was described in 1995 as:<br>• *Acacia aneura* low woodland on gentle slopes and plains;<br>• *Eucalyptus leucophloia* low open woodland in gullies, flowlines and broad creeklines;<br>The survey recorded a total of 206 species. Three of these were species of interest; *Goodenia stellata, Eremophila phyllopoda* ssp. *oblique* and *Acacia* aff. *citrinoviridis.* None remain on the Priority Flora list. |
| *Flora and vegetation surveys of Orebody A and Orebody B in the West Angela Hill area, an area surrounding them, and of rail corridor options considered to link them to the existing rail line*<br>M. Trudgen (1998) | Survey of the vegetation and flora present at Deposits A and B and surrounds, the access road and part of the rail conducted between 6 and 11 May 2004, covering a total area of approximately 42,000 ha.<br>Seven broad vegetation associations were described in 1998, based on vegetation and landforms:<br>• Vegetation of major and moderate flowlines;<br>• Vegetation of iron bearing formations;<br>• Vegetation of valleys, plains, low foothills and escarpments; |

| Report Title, Author and Year | Summary of Studies |
|---|---|
| | • Vegetation of volcanic formations;<br>• Vegetation of the Lyre Creek Agglomerate Member;<br>• Vegetation of recent epoch flood deposits and travertine areas; and<br>• Vegetation of the Wittenoom Formation;<br>The survey recorded a total of 635 species of flora. Twenty-one of these were Priority Flora, however, only five remain on the Priority Flora list:<br>• *Spartothamnella puberula* ((F.Muell.) Maiden & Betche)) (Parks and Wildlife Priority (**P)** 2);<br>• *Olearia mucronata* (Lander) (P3);<br>• *Dampiera metallorum* (Lepschi & Trudgen), previously *Dampiera* sp. Mt Meharry (M.E. Trudgen 1178) (P3);<br>• *Indigofera gilesii* sp. *gilesii* (P3); and<br>• *Eremophila magnifica*.<br>The DRF species *Lepidium catapycnon* was also recorded at the southern base of West Angela Hill. The total population recorded was in excess of 100 individuals in several patches, with populations extending upslope. |
| *Vegetation and Flora Survey of West Angelas Deposits E and F.*<br>Biota (2006) | Desktop review and single phase survey of the vegetation and flora present at Deposits E and F conducted between 6 and 11 May 2004, covering a total area of approximately 2,000 ha; rare flora searches conducted in June 2004 and between August and October 2005 in accordance with the following:<br>• EPA Position Statement No. 3: *Terrestrial Biological Surveys as an Element of Biodiversity Protection* (EPA 2002).<br>• EPA Guidance Statement No. 51: *Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia* (EPA 2004a).<br>Twelve vegetation types were identified in 2006, broadly these vegetation types included:<br>• Hard Spinifex *Triodia wiseana* and Soft Spinifex *Triodia pungens* or *Triodia* sp. Mt. Ella hummock grasslands with a scattered to moderately dense shrub overstorey dominated by varying proportions of *Acacia maitlandii, A. bivenosa* and *A. hamersleyensis* on stony hills in the northern section of the study area;<br>• Low woodlands to tall shrublands of *Acacia catenulata* in gorges;<br>• Hummock grasslands of *Triodia* aff. *basedowii*, with some *T. pungens*, on stony baseslopes; |

| Report Title, Author and Year | Summary of Studies |
|---|---|
| | • Woodlands to tall shrublands of various forms of Mulga *Acacia aneura* over open hummock grasslands, usually of *Triodia pungens*, on clayey soils of the broad valleys in the southern section of the study area; and<br>• Creeklines supporting tall shrublands dominated by various combinations of *Acacia maitlandii, Gossypium robinsonii, Petalostylis labicheoides* and *Rulingia luteiflora* over open hummock grasslands of *Triodia pungens*.<br>None of the vegetation types identified were considered to be sufficiently rare or restricted to warrant designating them as being of high conservation significance. The following vegetation types were considered to have moderate conservation significance:<br>• Mulga vegetation types M1-M5: these mapping units include the vegetation unit 6adb213 of Trudgen and Casson (1998), which was considered to be relatively restricted in the area, and also comprise ecosystems at risk in the form of grove/intergrove and valley floor mulga.<br>• Vegetation types Hi and H3 of stony hills and gorges respectively: these comprised the main mapping units from which the undescribed spinifex species *Triodia* sp. Mt Ella was recorded. This Priority 3 taxon is known only from the vicinity of West Angelas, and is apparently uncommon and restricted in distribution. It can therefore be surmised that any vegetation type in which this species is a significant component will also be uncommon and restricted.<br>The remainder of the vegetation types were considered to be of low conservation significance, representing units that are likely to be widely distributed and relatively well represented in the Hamersley Range subregion.<br>The survey recorded a total of 429 species of flora. Eight of these were Priority Flora, however, only five remain on the Priority Flora list:<br>• *Josephinia* sp. Marandoo (M.E. Trudgen 1554) (P1);<br>• *Spartothamnella puberula* (P2);<br>• *Indigofera gilesii* subsp. *gilesii* (P3);<br>• *Themeda* sp. Hamersley Station (M.E. Trudgen 11431) (P3); and<br>• *Triodia* sp. Mt Ella (M.E. Trudgen 12739) (P3).<br>All of these Priority Flora have been recorded previously from West Angelas. |

| | |
|---|---|
| *Greater West Angelas Vegetation and Flora Assessment*.<br>*ecologia* Environment (2013)<br>**Appendix 4** | Desktop review and two phase, Level 2 survey conducted; Phase 1 conducted between 9 and 18 July 2012, Phase 2 conducted between 21 and 26 August 2012, covering a total area of approximately 17,600 ha in accordance with the following:<br>• EPA Position Statement No. 3: Terrestrial Biological Surveys as an Element of Biodiversity Protection (EPA 2002).<br>• EPA Guidance Statement No. 51: *Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia* (EPA 2004a).<br>The results of this survey are outlined below. |

*Ecologia* Environment (***ecologia***) most recently conducted a two phase vegetation and flora assessment in 2012, covering a survey area of approximately 17,600 ha. The survey area is considerably broader than the Proposal. The survey was undertaken to support an environmental impact assessment and was conducted in accordance with EPA Position Statement No. 3: *Terrestrial Biological Surveys as an Element of Biodiversity Protection* (2002) and EPA Guidance Statement No. 51 - *Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia* (2004a).

### 5.1.1 IBRA Bioregions and Subregions

The survey area is situated within the Pilbara (**PIL**) Bioregion as defined in the Interim Biogeographic Regionalisation of Australia (**IBRA**) Report (Australian Government Department of Sustainability 2012). The Pilbara biogeographic region comprises four subregions: Chichester (PIL1); Fortescue Plains (PIL2); Hamersley (PIL3); and Roebourne (PIL4). The survey area is situated within the Hamersley subregion.

### 5.1.2 Beards Vegetation Mapping

The survey area lies entirely within the Pilbara region of the Eremaean Botanical Province as defined by Beard (1975). The vegetation of this province is typical of arid landscapes.

According to Beard the predominant vegetation associations in the survey area are:

- Low woodland; continuous Mulga *Acacia aneura* woodland communities over spinifex *Triodia basedowii* and *Triodia epactia* hummock grasslands on stony undulating plains; and
- Low scattered tree steppe; Snappy Gum *Eucalyptus leucophloia* over spinifex *Triodia wiseana* hummock grassland on stony undulating plains.

At a scale of 1: 1,000,000 the vegetation units described by Beard (1975) within the survey area are well represented elsewhere.

### 5.1.3 Land systems

Land systems comprise a series of ‘land units’ that occur on characteristic physiographic types within the land system. Land Systems mapping covers the survey area. The Study Area crosses the northern boundary of the area surveyed by Payne et al (1982) in the Regional Inventory of the Ashburton Rangelands and into the area surveyed by Van Vreeswyk et al. (2004) in the Regional Inventory of the Pilbara Rangelands.

Of the one hundred and seven Land Systems that have been identified in the Pilbara, seven occur within the survey area: Boolgeeda; Egerton; Elimunna; Newman; Platform; Rocklea; and Wannamunna, with the Newman and Boolgeeda land systems being the most extensive.

Regionally the majority of the area within each of these land systems was assessed to be in good or very good condition.

### 5.1.4 Vegetation

Twenty-two vegetation types were described within the survey area (*ecologia* 2012). Seventeen of these vegetation types are considered to be of relevance to this Proposal (Table 5-2).

**Table 5-2: Vegetation types (*ecologia* 2012)**

| Vegetation Mapping Code | Vegetation Description (NVIS Level V) |
|---|---|
| **Gravely Plains** | |
| ApTb | ***Acacia open woodland over Triodia open hummock grassland***.<br>*Acacia aptaneura* and *A. pruinocarpa* open woodland over *A. bivenosa* isolated shrubs *Triodia basedowii* and *T. pungens* open hummock grassland. |
| SggGrTp | ***Senna* and *Acacia* open shrubland over *Triodia* hummock grassland.**<br>*Acacia pruinocarpa* and *Eucalyptus leucophloia* subsp. *leucophloia* or *Corymbia hamersleyana* isolated trees over *Senna glutinosa* subsp. *glutinosa, Acacia bivenosa* and *Gossypium robinsonii* open shrubland over *Triodia pungens* hummock grassland |
| **Rocky Footslopes / Rises** | |
| AaSggEp | ***Acacia* open woodland over *Triodia* open hummock grassland.**<br>*Acacia aptaneura* and *A. pruinocarpa* open woodland over *A. tetragonophylla, Senna glutinosa* subsp. *glutinosa* and *S. artemisioides* subsp. *oligophylla* isolated shrubs over *Triodia wiseana* and *T. pungens* open hummock grassland. |
| **Rocky Hilltops** | |
| AiSggTw | ***Eucalyptus* open woodland over *Senna* open shrubland over *Triodia* open hummock grassland.**<br>*Eucalyptus leucophloia* subsp. *leucophloia* and *Acacia aptaneura* open woodland over *Senna glutinosa* subsp. *glutinosa* and *S. artemisioides* subsp. *oligophylla* open shrubland over *Triodia wiseana* or *T. pungens* open hummock grassland. |
| AmGtTssp | **Eucalyptus open woodland over Senna open shrubland over Triodia open hummock grassland.**<br>*Eucalyptus leucophloia* subsp. *leucophloia* and *E. gamophylla* open woodland over *Acacia maitlandii, A. hamersleyensis, Keraudrenia velutina* and *Senna glutinosa* subsp. *glutinosa* open shrubland over *Triodia wiseana* and/or *T. pungens* and/or *T. basedowii* open hummock grassland. |
| **Rocky Midslope** | |
| AaEffTp | ***Acacia* open woodland over *Eremophila* sparse shrubland and *Triodia* sparse hummock grassland.**<br>*Acacia aptaneura* and *A. pruinocarpa* open woodland over sparse *Eremophila fraseri* subsp. *fraseri* and *Acacia marramamba* sparse shrubland over *Triodia pungens* sparse hummock grassland. |
| AbPrIa | ***Triodia* hummock grassland.**<br>*Eucalyptus leucophloia* subsp. *leucophloia* and *Acacia pruinocarpa* isolated trees over *Senna glutinosa* subsp. *glutinosa, A. bivenosa* and *Ptilotus rotundifolius* isolated shrubs over *Triodia pungens* or *T. basedowii* or *T.* sp. Mt Ella hummock grassland. |
| ChDlTt | ***Senna* sparse shrubland over *Triodia* open hummock grassland.**<br>*Eucalyptus leucophloia* subsp. *leucophloia* and *Corymbia hamersleyana* isolated trees over *Senna glutinosa* subsp. *glutinosa* and *Acacia maitlandii* sparse shrubland over *Triodia pungens* open hummock grassland. |
| **Sandy Floodplains / Dry Rivers** | |
| AaPoEp | ***Acacia* open woodland over *Ptilotus* sparse shrubland over *Themeda* open tussock grassland.**<br>*Acacia aptaneura* open woodland over *Ptilotus obovatus* sparse shrubland over *Themeda triandra* open tussock grassland. |

| Vegetation Mapping Code | Vegetation Description (NVIS Level V) |
|---|---|
| ExPnnTt | ***Acacia* woodland over *Themeda* open tussock grassland.**<br>*Acacia aptaneura* and *Eucalyptus xerothermica* woodland over *Ptilotus obovatus* isolated shrubs over *Themeda triandra* open tussock grassland. |
| **Floodplains / Drainage Lines** | |
| AaAoAc | ***Acacia* open woodland over *Aristida* sparse tussock grassland.**<br>*Acacia aptaneura* and *A. pruinocarpa* open woodland over *Aristida contorta* sparse tussock grassland over *Pterocaulon sphacelatum* and *Ptilotus nobilis* subsp. *nobilis* isolated forbs. |
| AaSaoTp | ***Acacia* open woodland over *Senna* sparse shrubland over *Triodia* open hummock grassland.**<br>*Acacia aptaneura* and *A. ayersiana* open woodland over *Senna artemisioides* subsp. *oligophylla, S. glutinosa* subsp. *glutinosa* and *Eremophila forrestii* subsp. *forrestii* sparse shrubland over *Triodia pungens* open hummock grassland. |
| EgKvPm | ***Eucalyptus* open woodland over *Senna* sparse shrubland over *Triodia* open hummock grassland.**<br>*Eucalyptus gamophylla* and *Corymbia deserticola* subsp. *deserticola* open woodland over *Senna artemisioides* subsp. *oligophylla* and *Indigofera monophylla* sparse shrubland over *Triodia basedowii* and *T. pungens* open hummock grassland. |
| **Sandy Plain** | |
| ApEcTp | ***Acacia* open woodland over *Eremophila* isolated shrubs over *Triodia* open hummock grassland.**<br>*Acacia aptaneura* and *A. pruinocarpa* open woodland over *Eremophila caespitose* and *Tribulus suberosus* isolated shrubs over *Triodia pungens* open hummock grassland. |
| PnnAp | ***Aristida* and *Astrebla* tussock grassland.**<br>*Aristida latifolia, Astrebla pectinata* and *Brachyachne convergens* tussock grassland with isolated *Salsola australis, Boerhavia paludosa* and *Ptilotus nobilis* subsp. *nobilis* forbs. |
| PsAjs | ***Pterocaulon* sparse forbland with *Triodia* open hummock grassland.**<br>*Acacia aptaneura* or *A. ayersiana* open woodland over *Pterocaulon sphacelatum* and *Dysphania kalparri* sparse forbland with *Triodia pungens* open hummock grassland. |
| **Sandy Undulating Plain** | |
| AaSlTp | ***Acacia* woodland over *Triodia* open hummock grassland.**<br>*Acacia pruinocarpa, A. aptaneura* and *A. ayersiana* woodland over *Triodia pungens* open hummock grassland. |

The vegetation mapping is shown in Figure 5-1.

West Angelas is not located within a pastoral lease and, as a result, is not actively grazed. Subsequently, the vegetation condition was assessed to be in very good to excellent condition (*ecologia* 2012). The disturbance most commonly observed was the presence of weed species. Nine weeds were recorded, all of which have been assessed using an Environmental Threat Assessment for the Pilbara Bioregion (based on Parks and Wildlife's Environmental Weeds list). Three species are ranked as a high threat: *Cenchrus ciliaris* (buffel grass); *Cenchrus setiger* (birdwood grass); and *Vachellia farnesiana* (mimosa bush). *Biden's bipinnata* is by far the most abundant weed species recorded in the region.

A total of 441 species were recorded from the region. The pattern of representation is considered typical for the Pilbara. The most common families were: Poaceae (grass family) with 76 species recorded; Fabaceae (pea family) with 72 species recorded; Malvaceae with 46 species recorded; Asteraceae with 27 species recorded; Amaranthaceae with 23 species recorded; Chenopodiaceae with 20 species recorded; Scrophulariaceae with 17 species recorded; Goodeniaceae with 14 species recorded; and Myrtaceae with 14 species recorded. The large number of taxa within the family Scrophulariaceae reflects the abundance of mulga woodlands and shrublands, within which most of these species occur. The relatively high representation of Asteraceae, Amaranthaceae and Goodeniaceae is a reflection of the optimal timing of the survey when many ephemeral species were flowering.

## 5.2 CONSERVATION SIGNIFICANT VEGETATION

No Threatened Ecological Communities (**TECs**) are known to occur within the region. The single vegetation TEC that has been recorded from the Hamersley subregion (*Themeda* sp. Hamersley Station grasslands; listed as Vulnerable) has not been recorded within the Proposal area and is not considered likely to exist.

The P1 West Angelas Cracking Clay Priority Ecological Community (**PEC**) occurs extensively within the region. Figure 5-1 depicts the extent of recorded PEC's within the Proposal area. This community is defined as 'open tussock grasslands of *Astrebla pectinata*, *A. elymoides*, *Aristida latifolia* in combination with *Astrebla squarrosa* and low scattered shrubs of *Sida fibulifera*, on basalt derived cracking-clay loam depressions and flowlines'. The vegetation unit PnnAp (*Aristida* and *Astrebla* grassland) has been determined to be equivalent to the Cracking Clay PEC despite the lack of *A. elymoides* which was not recorded during the 2012 survey. It is thought that the survey timing for tussock grasses may not have been optimal with reproductive material often being absent and identifications problematic for this group.

The West Angelas Cracking Clays are significant because they are relatively uncommon in the region and because they are in very good condition, attributed to the absence of historic cattle grazing. Threats to this community include: clearing for mining expansion and future infrastructure development; weed invasion; and changes in fire regimes.

The West Angelas Cracking Clay PEC is not proposed to be detrimentally impacted by the Proposal. Deposit A west has been designed to avoid intersecting the PEC. Some reduction of catchment to the Cracking Clay PEC is expected; however, modelling indicates that the PEC is not dependant on this catchment. The hydrological interaction is further discussed in Section 7.

Numerous additional ecosystems are deemed to be "ecosystems at risk" (Kendrick 2003) and are therefore considered locally significant. Of these, the following ecosystems are relevant to the Proposal area:

- Grove/intergrove mulga communities: The grove/intergrove mulga in the region is in very good condition however, this vegetation is considered to be under threat from grazing and trampling, weed ingress (particularly by Ruby Dock **Acetosa vesicaria*), and changes to hydrological regimes. Grove/intergrove Mulga communities are widely recognised as being dependent on patterns of surface water flow. The diversion of sheet flow or concentration of sheet flow to particular areas is likely to cause shadowing impacts on these mulga communities.

- Valley floor mulga: "Valley floor mulga" is a very broad description of mulga communities (previously *Acacia aneura* but now including a number of species). Valley floor mulga is also recognised as being dependent on patterns of surface water flow and is considered to be under threat from the same factors listed above.

The Proposal intersects valley floor mulga identified as being of moderate conservation significance. The conservation status of valley floor mulga is not proposed to be detrimentally impacted by the Proposal given the wide distribution of this community in the region. Some reduction of catchment to valley floor mulga is also expected. The hydrological interaction is further discussed in Section 7.

Vegetation was also considered to be locally significant if it had "a role as a key habitat for threatened species". The following vegetation units were all considered by *ecologia* (2012) to be locally significant due to the rarity of the species they support:

- *Aristida jerichoensis* var. *subspinulifera* (P1), although being present within 10 vegetation units, demonstrates a higher specificity to unit *AaTp* (sandy undulating plains).
- *Indigofera* sp. Gilesii (M.E. Trudgen 15869) demonstrates specificity for the vegetation unit *ChDlTt,* rocky midslopes.
- *Sida* sp. Barlee Range (S. van Leeuwen 1642) favoured vegetation unit *AaEm,* which is only found in gullies and gorges.
- Vegetation units *SggIrTw* (rocky hilltops) and *ApEcTp* (sandy plains) support five individual threatened and/or priority taxa.
- Collectively, these units account for eight out of the 13 Threatened and Priority Flora recorded in the survey: *Aristida jerichoensis* var. *subspinulifera*; *Brachyscome* sp. Wanna Munna Flats; *Brunonia* sp. long hairs; *Goodenia nuda, Indigofera* sp. Gilesii (M.E. Trudgen 15869); *Lepidium catapycnon*; *Rhagodia* sp. Hamersley; and *Sida* sp. Barlee Range.

The Proposal intersects some of the vegetation considered to be locally significant due to the presence of Priority Flora. Robe considers that the assessment of community significance based on the presence of Priority Flora could be considered valid for vegetation containing habitat restricted flora, however, this approach is considered questionable for vegetation containing Priority Flora that is not habitat restricted.

### 5.3 CONSERVATION SIGNIFICANT FLORA

No flora listed under the under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (**EPBC Act**), or gazetted as DRF (Threatened) under the Western Australian *Wildlife Conservation Act 1950* (**WC Act**) were recorded or are expected to occur within the Proposal area.

A total of 29 individuals of *Lepidium catapycnon* (EPBC Vulnerable and WC Act Vulnerable), were collected opportunistically from four locations where vegetation and landforms are consistent with this species' habitat. *L. catapycnon* is also known to occur more broadly in the region. The main threat to *L. catapycnon* is mining and exploration activities as the majority of recorded populations occur within mining and exploration tenements, although records are known from Karijini National Park. The spread of the introduced species *Acetosa vesicaria* (Ruby Dock, which was also recorded) has been suggested to prevent establishment of this species in some areas. However none of the records of this species were relevant to the Proposal.

The following Threatened and Priority Flora taxa were recorded during the *ecologia* (2012) survey:

- three P1 species (*Aristida jerichoensis* var. *subspinulifera, Brachyscome* sp. Wanna Munna Flats (S. van Leeuwen 4662) and *Brunonia* sp. long hairs (D.E. Symon 2440));
- two P2 species (*Aristida lazaridis* and *Eremophila forrestii* subsp. Pingandy (M.E. Trudgen 2662));
- six P3 species (*Acacia* aff. *subtiliformis, Indigofera* sp. Gilesii (M.E. Trudgen 15869)*, Rhagodia* sp. Hamersley (M. Trudgen 17794), *Sida* sp. Barlee Range (S. van Leeuwen 1642), *Themeda* sp. Hamersley Station (M.E. Trudgen 11431) and *Triodia* sp. Mt Ella (M.E. Trudgen 12739); and
- one P4 species (*Goodenia nuda*).

Seven of these species have previously been recorded within the region.

Additionally, four Priority species were assessed as having a high likelihood of occurrence, based on previous records: *Tetratheca fordiana* (P1); *Dampiera metallorum* (P3); *Goodenia* sp. East Pilbara (A.A. Mitchell PRP 727) (P3); and *Oldenlandia* sp. Hamersley Station (A.A. Mitchell PRP 1479) (P3).

New clearing for the Proposal intersects only nine recorded Priority taxa, as follows:

- *Aristida jerichoensis* var. *subspinulifera* (P1);
- *Brachyscome* sp. Wanna Munna Flats (S. van Leeuwen 4662) (P1);
- *Brunonia* sp. long hairs (D.E. Symon 2440) (P1);
- *Aristida lazaridis* (P2);
- *Indigofera gilesii* subsp. *gilesii* (P3) ;
- *Themeda* sp. Hamersley Station (M.E. Trudgen 11431) (P3);
- *Triodia* sp. Mt Ella (M.E. Trudgen 12739) (P3);
- *Rhagodia* sp. Hamersley (M. Trudgen 17794) (P3); and
- *Goodenia nuda* (P4).

Figure 5-2 depicts recorded Priority Flora within the Proposal area.

Based on current records of the Western Australian Herbarium (Florabase), five of the Priority Flora recorded are not represented within conservation estates (*Aristida jerichoensis* var. *subspinulifera*, *Brachyscome* sp. Wanna Munna Flats, *Brunonia* sp. long hairs, *Indigofera gilesii subsp. gilesii* and *Triodia* sp. Mt Ella). These taxa are considered to be of higher conservation significance, irrespective of the fact that they are locally common in preferred habitat, which is considered relatively widespread within the region.

Some occurrences of Priority flora are expected to be disturbed by the proposed clearing however, the Proposal will preferentially avoid known locations of Priority flora as far as practicable.

**Table 5-3: Flora and Vegetation: Description of Factor, Impact Assessment and Management**

| EPA Objective | Existing Environment | Potential Impacts (without mitigation) | Management and Outcome |
|---|---|---|---|
| *To maintain representation, diversity, viability and ecological function at the species population and community level.* | Vegetation and flora surveys have been undertaken across the West Angelas region since 1979. *ecologia* recently completed a two-phase vegetation and flora assessment in 2012. A summary of the findings of the surveys that are relevant to the Proposal are provided below.<br>**Vegetation**<br>Twenty-two vegetation types were mapped in the area. Seventeen of these vegetation types are considered to be of relevance to the Proposal.<br>The West Angelas Cracking Clay Priority Ecological Community (**PEC**) has been identified as occurring extensively throughout the area. This community is defined as 'open tussock grasslands of *Astrebla pectinata, A. elymoides, Aristida latifolia* in combination with *Astrebla squarrosa* and low scattered shrubs of *Sida fibulifera*, on basalt derived cracking-clay loam depressions and flowlines'.<br>None of the other vegetation types identified were considered to be of high conservation significance. The grove/intergrove and valley floor mulga communities were considered to have moderate conservation significance. The remainder of the vegetation types were considered to be of low conservation significance, representing units that are likely to be widely distributed and relatively well represented in the region. Vegetation communities were generally found to be in Very Good to Excellent condition despite evidence of weed invasion.<br>**Flora**<br>No flora listed under the under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (**EPBC Act**), or gazetted as Declared Rare Flora (Threatened) under the Western Australian *Wildlife Conservation Act 1950* (**WC Act**) were recorded or are expected to occur within the Proposal area however, 10 Priority taxa were recorded, including:<br>• *Aristida jerichoensis* var. *subspinulifera* (P1)<br>• *Brachyscome* sp. Wanna Munna Flats (S. van Leeuwen 4662) (P1)<br>• *Brunonia* sp. long hairs (D.E. Symon 2440) (P1)<br>• *Aristida lazaridis* (P2)<br>• *Eremophila forrestii* subsp. *Pingandy* (M.E. Trudgen 2662) (P2)<br>• *Indigofera gilesii* subsp. *gilesii* (P3)<br>• *Themeda* sp. Hamersley Station (M.E. Trudgen 11431) (P3)<br>• *Triodia* sp. Mt Ella (M.E. Trudgen 12739) (P3)<br>• *Rhagodia* sp. Hamersley (M. Trudgen 17794) (P3)<br>• *Goodenia nuda* (P4).<br>Five of these Priority flora taxa are not represented within conservation estates (*Aristida jerichoensis* var. *subspinulifera*, *Brachyscome* sp. Wanna Munna Flats, *Brunonia* sp. long hairs, *Indigofera gilesii subsp. gilesii* and *Triodia* sp. Mt Ella). These species are considered to be of higher conservation significance, irrespective of the fact that they are locally common in preferred habitat, which is considered relatively widespread within the region.<br>The vegetation and flora assessment report relevant to the Proposal is provided as Appendix 4. | **Clearing**<br>The Proposal will result in clearing of up to 3,220 ha of vegetation (in addition to that approved via MS 970), including vegetation communities which are considered to be of local conservation significance. Some occurrences of Priority flora species will also potentially be cleared.<br>The effect of the proposed change to vegetation and flora values is not considered significantly different or additional to that of the approved West Angelas Project as the potential impacts to flora and vegetation values are considered to remain unchanged from that assessed given the proposed changes will:<br>• Not affect any new vegetation communities that have not been previously assessed.<br>• Not affect any known PEC's in the area.<br>• Not affect any known occurrences of DRF and will minimise impacts to known locations of Priority species where practicable.<br>**Altered hydrological regime**<br>The West Angelas Cracking Clay PEC and valley floor mulga communities are recognised as being dependent on patterns of surface water flow. The hydrological interaction is further discussed in Section 7. | The key potential impact of the Proposal on vegetation and flora are loss through clearing.<br>The following key management measures from the Environmental Management Program (Appendix 7) have been, and will continue to be, implemented to manage potential impacts on vegetation and flora:<br>• Clearing will only occur within approval boundaries and limits.<br>• Clearing has, and will continue to, avoid areas of elevated conservation significance as far as practicable. Conservation significant areas include the following:<br>o West Angelas Cracking Clay Priority Ecological Community (PEC);<br>o grove / intergrove Mulga communities, and<br>o areas supporting Rare and / or Priority Flora.<br>• Known locations of DRF and Priority flora species have, and will continue to be, mapped to prevent disturbance as far as practicable.<br>• Where clearing of vegetation is unavoidable, areas will be progressively rehabilitated with local native vegetation where possible.<br>• Weed management has, and will continue to be undertaken as part of an annual weed control program and as otherwise required.<br>• Fire restrictions have, and will continue to be implemented.<br>Vegetation degradation as a result of hydrological changes will be minimised via management measures to reduce potential impacts on natural hydrological regimes, as detailed in Table 7-1.<br>**Outcome:**<br>The Revised Proposal can be managed to meet the EPA objective for this factor, in summary:<br>• No new or potentially significant environmental features have been recorded.<br>• Vegetation communities potentially impacted by the Proposal, including communities of local conservation significance, are well represented outside of the Proposal area on a local and regional scale.<br>• Clearing will be restricted to the extent authorised.<br>• Appropriate management measures to avoid, minimise and mitigate potential impacts of the Proposal on vegetation and flora have been, and will continue to be, implemented. |

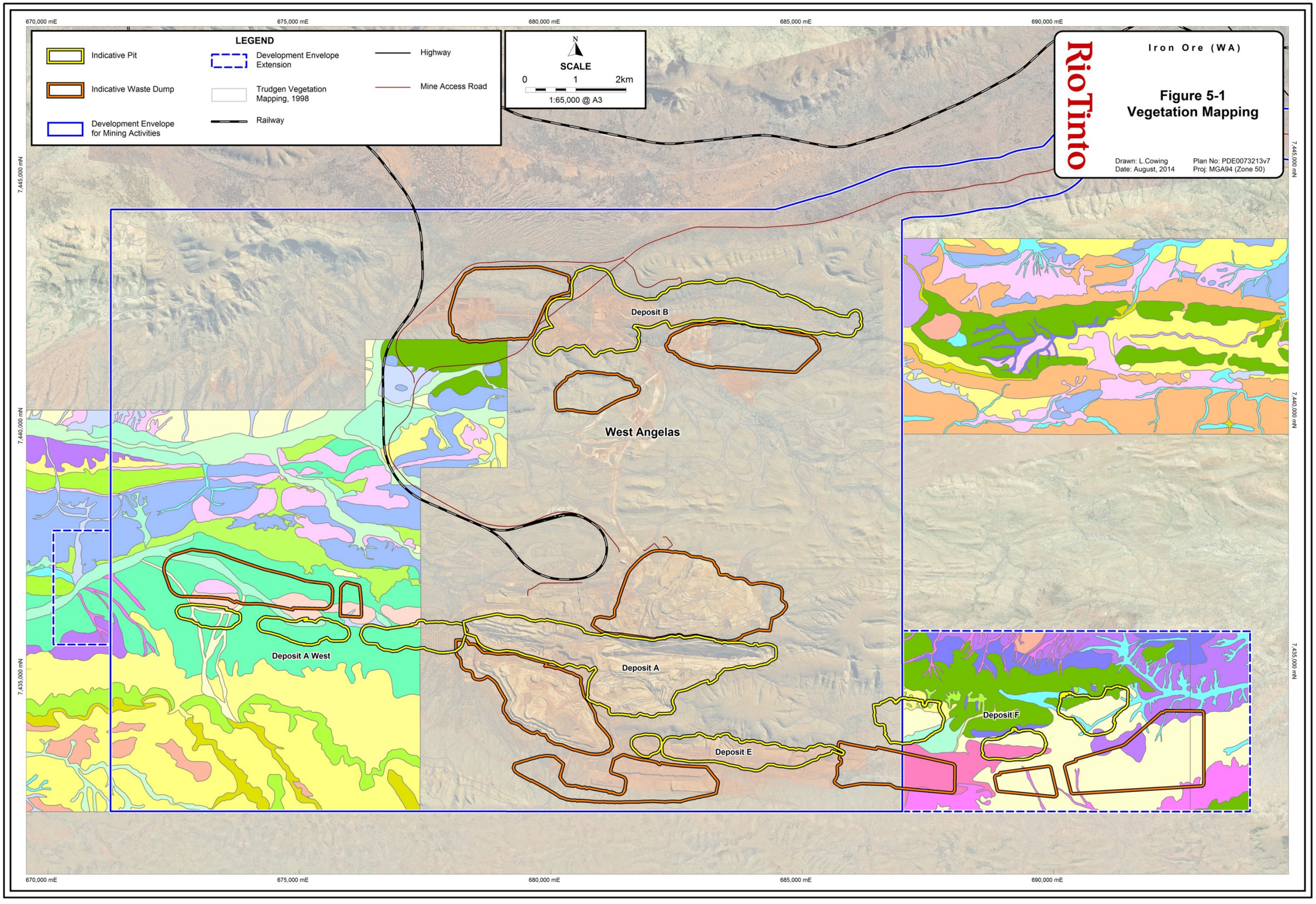
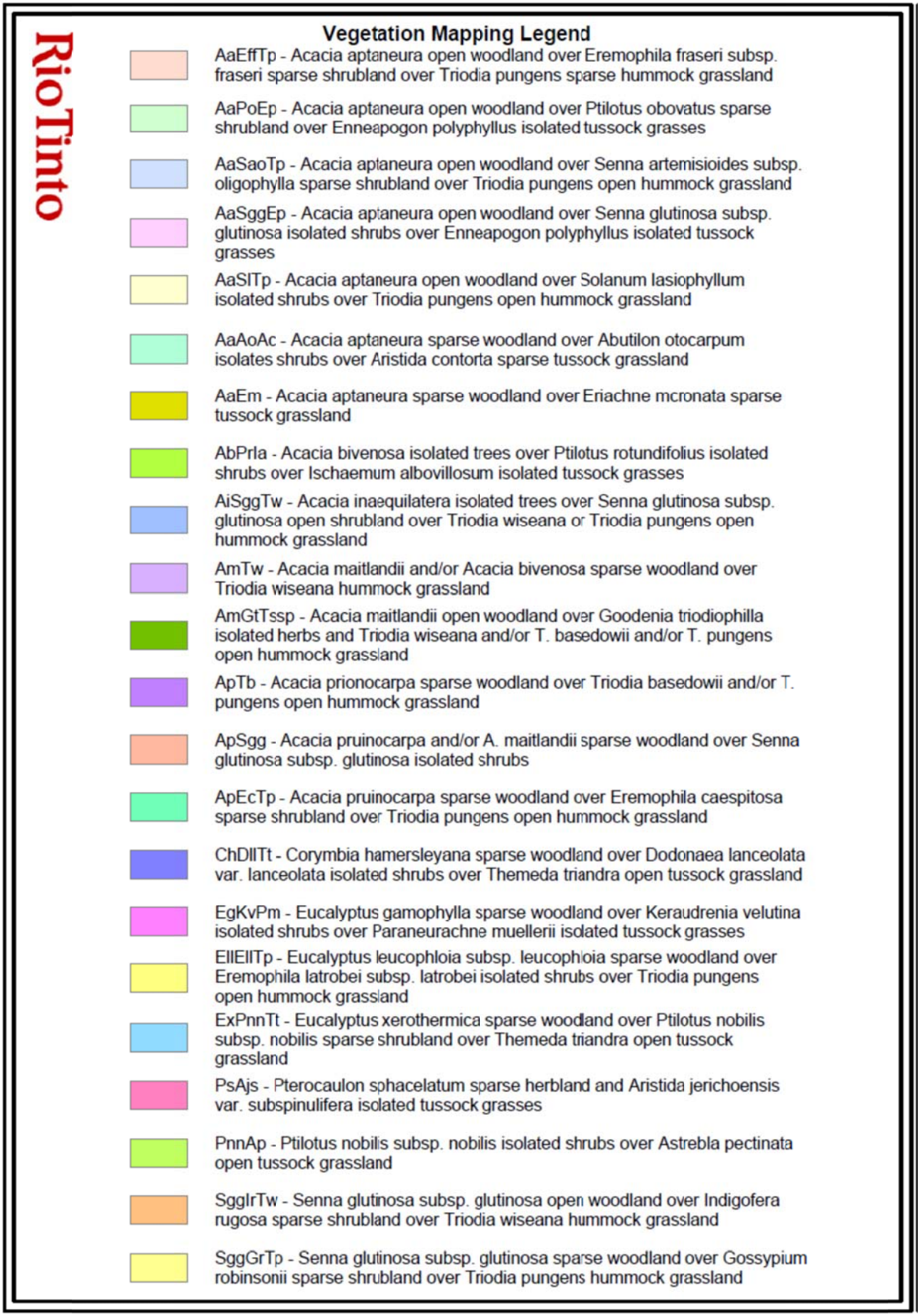



**Figure 5-1: Vegetation Mapping**


RioTinto
Vegetation Mapping Legend
AaEffTp - Acacia aptaneura open woodland over Eremophila fraseri subsp. fraseri sparse shrubland over Triodia pungens sparse hummock grassland
AaPoEp - Acacia aptaneura open woodland over Ptilotus obovatus sparse shrubland over Enneapogon polyphyllus isolated tussock grasses
AaSaoTp - Acacia aptaneura open woodland over Senna artemisioides subsp. oligophylla sparse shrubland over Triodia pungens open hummock grassland
AaSggEp - Acacia aptaneura open woodland over Senna glutinosa subsp. glutinosa isolated shrubs over Enneapogon polyphyllus isolated tussock grasses
AaSlTp - Acacia aptaneura open woodland over Solanum lasiophyllum isolated shrubs over Triodia pungens open hummock grassland
AaAoAc - Acacia aptaneura sparse woodland over Abutilon otocarpum isolates shrubs over Aristida contorta sparse tussock grassland
AaEm - Acacia aptaneura sparse woodland over Eriachne mcronata sparse tussock grassland
AbPrla - Acacia bivenosa isolated trees over Ptilotus rotundifolius isolated shrubs over Ischaemum albovillosum isolated tussock grasses
AiSggTw - Acacia inaequilatera isolated trees over Senna glutinosa subsp. glutinosa open shrubland over Triodia wiseana or Triodia pungens open hummock grassland
AmTw - Acacia maitlandii and/or Acacia bivenosa sparse woodland over Triodia wiseana hummock grassland
AmGtTssp - Acacia maitlandii open woodland over Goodenia triodiophilla isolated herbs and Triodia wiseana and/or T. basedowii and/or T. pungens open hummock grassland
ApTb - Acacia prionocarpa sparse woodland over Triodia basedowii and/or T. pungens open hummock grassland
ApSgg - Acacia pruinocarpa and/or A. maitlandii sparse woodland over Senna glutinosa subsp. glutinosa isolated shrubs
ApEcTp - Acacia pruinocarpa sparse woodland over Eremophila caespitosa sparse shrubland over Triodia pungens open hummock grassland
ChDllTt - Corymbia hamersleyana sparse woodland over Dodonaea lanceolata var. lanceolata isolated shrubs over Themeda triandra open tussock grassland
EgKvPm - Eucalyptus gamophylla sparse woodland over Keraudrenia velutina isolated shrubs over Paraneurachne muellerii isolated tussock grasses
EllEllTp - Eucalyptus leucophloia subsp. leucophloia sparse woodland over Eremophila latrobei subsp. latrobei isolated shrubs over Triodia pungens open hummock grassland
ExPnnTt - Eucalyptus xerothermica sparse woodland over Ptilotus nobilis subsp. nobilis sparse shrubland over Themeda triandra open tussock grassland
PsAjs - Pterocaulon sphacelatum sparse herbland and Aristida jerichoensis var. subspinulifera isolated tussock grasses
PnnAp - Ptilotus nobilis subsp. nobilis isolated shrubs over Astrebla pectinata open tussock grassland
SggIrTw - Senna glutinosa subsp. glutinosa open woodland over Indigofera rugosa sparse shrubland over Triodia wiseana hummock grassland
SggGrTp - Senna glutinosa subsp. glutinosa sparse woodland over Gossypium robinsonii sparse shrubland over Triodia pungens hummock grassland

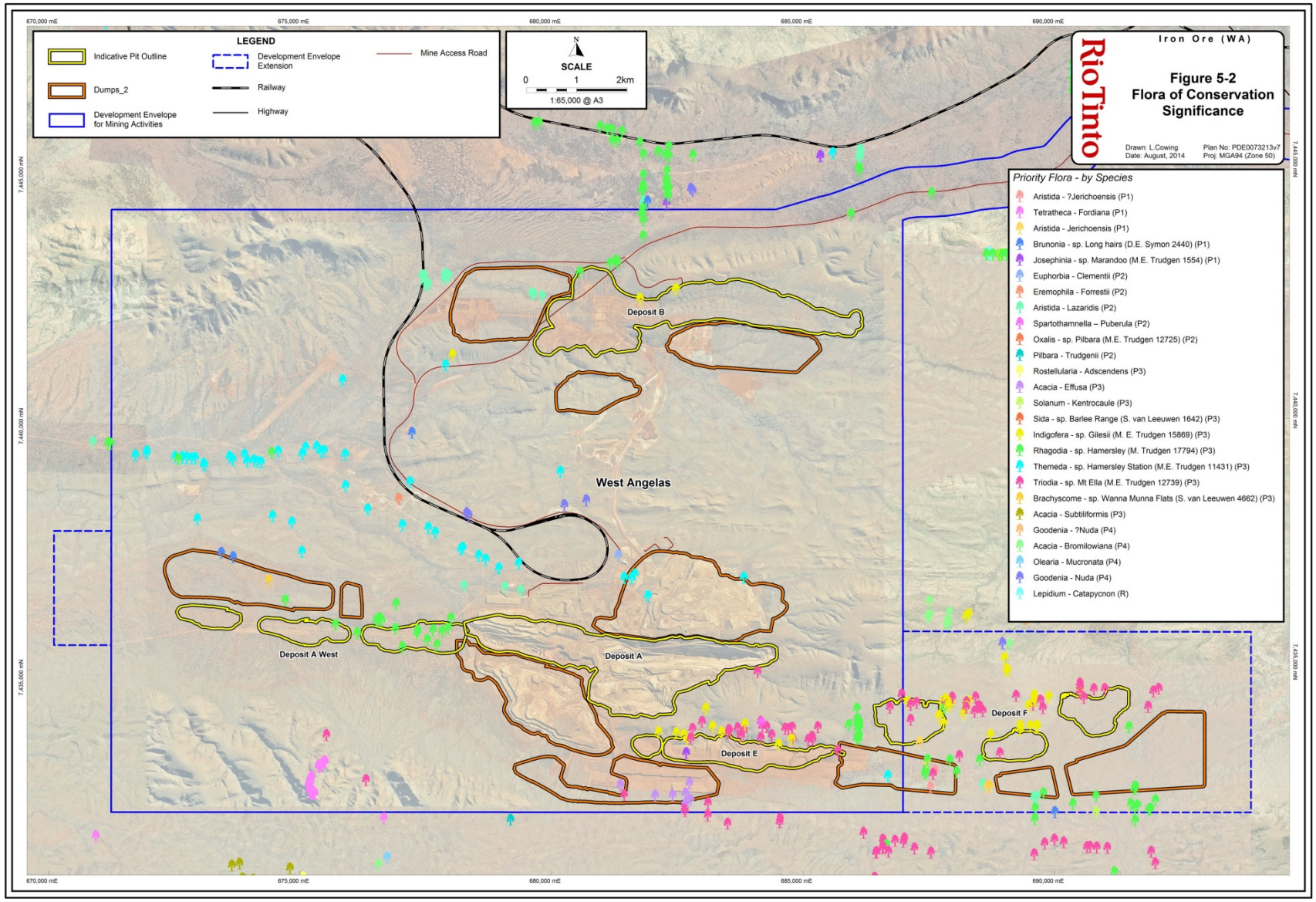



**Figure 5-2: Flora of Conservation Significance**

# 6 TERRESTRIAL FAUNA

This Section describes the terrestrial fauna and fauna habitats that occur within the Proposal area and provides details regarding the potential impacts to conservation significant fauna and fauna habitats from 3,220 ha of additional clearing that forms part of this Proposal.

The EPA applies the following objective from EAG 8 in its assessment of proposals that may affect terrestrial fauna:

> *To maintain representation, diversity, viability and ecological function at the species, population and assemblage level.*

Table 6-2 describes how the proposal meets the EPA's objectives in respect of terrestrial fauna and fauna habitats.

## 6.1 TERRESTRIAL FAUNA STUDIES

A number of fauna surveys have been undertaken across the West Angelas region since 1979. Table 6-1 summarises the key surveys relevant to this Proposal.

The combined coverage of these surveys has enabled a detailed understanding of the existing fauna and fauna habitats in the West Angelas region.

**Table 6-1: Summary of Supporting Studies**

| Report Title, Author and Year | Summary of Studies |
|---|---|
| *An ecological appreciation of the West Angelas environment, Western Australia 1979.*<br><br>Integrated Environmental Services (1978) | Strategic biological survey of vertebrate fauna conducted in all seasons of 1978 and 1979 across West Angelas. Survey of invertebrate fauna conducted December 1979. The fauna of the Pilbara was considered little known with few previous surveys in the region.<br><br>The vertebrate fauna survey recorded 15 species of mammals (including potential Western Pebble-mound Mice *Pseudomys chapmani*), an additional three species of bats, 25 species of reptiles, two species of amphibians and 48 species of birds. The fauna was considered to consist of largely common and widespread species. However the following species were considered to be of importance: populations of Brush-tailed Rock Wallabies *Petrogale penicillata*; Ingram's Planigales *planigale* sp. (*ingrami*); Pebble Mound Mice *Pseudomys* sp.; Ghost Bats *Macroderma gigas;* the skink *Lerista neader;* Australian Bustard *Ardeotis australis;* and Grey Falcon *Falco hypoleucos*.<br><br>The invertebrate fauna survey mostly recorded species that were considered relatively common in the Pilbara. However, some of the species had not been previously collected. It was not possible to make statements about the status of species given that little was known about the invertebrate fauna of the Pilbara. |
| *West Angelas Project Vertebrate Fauna Assessment Survey*.<br><br>*ecologia* (1998) | Extensive vertebrate fauna and fauna habitat assessment conducted between June and October 1997, across West Angelas (including the rail corridor) in accordance with EPA requirements for biological inventory and assessment and CALM biological survey guidelines for the Pilbara.<br><br>Eight primary habitats, largely based on vegetation and landforms, were identified:<br>• Mulga Woodland;<br>• Rocky Gully;<br>• Cracking Clay;<br>• Creekline;<br>• Hilltop;<br>• Spinifex Plain;<br>• Riverine; and<br>• Boulder Hill. |

| Report Title, Author and Year | Summary of Studies |
|---|---|
| | Cracking Clay habitat was considered to be regionally significant, supporting specialist fauna. Mulga Woodland forms habitat for a diverse fauna assemblage and was also considered to be of regional significance. Other areas identified as being important for fauna included caves for Ghost Bats and Pebble-mound Mouse habitat.<br><br>The survey recorded 119 species of terrestrial vertebrate fauna, comprising: 21 mammals; 27 reptiles; one amphibian; and 70 birds. An additional 12 mammals; 48 reptiles; one amphibian; and 47 birds were recorded in the rail corridor. Two Priority listed species were recorded from the survey area: the Ghost Bat *Macroderma gigas* (P4); and Western Pebble-mound Mouse *Pseudomys chapmani* (P4). Four additional Priority listed species: the Rainbow Bee-eater *Merops ornatus* (EPBC Migratory, WC Act Schedule 3); Grey Falcon *Falco hypoleucos* (P4)*;* Bush Stone-curlew *Burhinus grallarius* (P4); and Lined Soil-crevice Skink *Notoscincus butleri* (P4) were recorded in the rail corridor. |
| *Fauna Habitats and Fauna Assemblage of Deposits E and F at West Angelas.*<br><br>Biota (2005) | Desktop review and single phase survey of the fauna habitats and fauna assemblage present at Deposits E and F conducted between 4 and 12 May 2004 in accordance with the following:<br><br>• EPA Position Statement No. 3: *Terrestrial Biological Surveys as an Element of Biodiversity Protection* (EPA 2002).<br><br>• EPA Guidance Statement No. 56: *Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia* (EPA 2004b).<br><br>Four primary habitats, largely based on vegetation structure and landforms, were identified:<br><br>• Broad colluvial valleys dominated by Acacia aneura;<br><br>• Lower stony footslopes at the interface between Acacia dominated and eucalypt dominated communities;<br><br>• Stony hilltops and upper slopes dominated by eucalypts over *Triodia*; and<br><br>• Incised gullies and creeks.<br><br>One fauna habitat is considered to have moderate conservation significance within the study area, based on the vegetation types to which it relates; Broad colluvial valleys dominated by *Acacia aneura* comprise ecosystems at risk in the form of grove/intergrove and valley floor mulga.<br><br>The survey recorded 98 species of terrestrial vertebrate fauna, comprising 12 mammals including one bat, 37 reptiles and 47 birds. Two Priority listed species were recorded from the survey area: the Australian Bustard *Ardeotis australis* (P4) and Western Pebble-mound Mouse *Pseudomys chapmani* (P4). The survey also documented one key group of invertebrates, the Mygalomorphae (trapdoor spiders), potentially supporting narrow range taxa. |

| Report Title, Author and Year | Summary of Studies |
|---|---|
| *Greater West Angelas Terrestrial Fauna Assessment*.<br>*ecologia* (2014)<br>**Appendix 5** | Desktop review and two phase, Level 2 survey conducted; Phase 1 conducted between 26 September and 6 October 2012, Phase 2 conducted between 18 and 27 March 2013 in accordance with the following:<br>• EPA Position Statement No. 3: Terrestrial Biological Surveys as an Element of Biodiversity Protection (EPA 2002).<br>• EPA Guidance Statement No. 56: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia (EPA 2004b).<br>• Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment, Guidance Statement 20: Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia (EPA 2009).<br>The results of the survey are outlined below. |

*Ecologia* (2014) most recently conducted a terrestrial fauna assessment in 2012 and 2013. The survey was conducted in accordance with EPA Position Statement No. 3: *Terrestrial Biological Surveys as an Element of Biodiversity Protection* (EPA 2002), EPA Guidance Statement No. 56: *Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia* (EPA 2004b) and EPA Guidance Statement No. 20: *Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia* (EPA 2009).

West Angelas is acknowledged to support diverse fauna for its size due to the variety of relief and geological types which combine to provide a great diversity of habitats. Nine broad-scale habitat types have been identified across the region, largely based on vegetation structure and landform: 'footslope or plain'; 'hilltop, hillslope, ridge or cliff'; 'mixed Acacia woodland'; 'mesa top'; 'cracking clay'; 'major gorge and gully'; 'major drainage'; 'mulga woodland'; and 'cleared area'.

Five of the broad-scale habitat types identified are considered to be of relevance to the Proposal:

- Footslope or plain – the vegetation cover on this habitat is typically comprised of *Eucalyptus leucophloia, E. gamophylla, Corymbia hamersleyana, A. pruinocarpa, A inaequilatera* and species in the *A. aneura* complex open woodland to sparse trees over *Acacia* spp*., Eremophila* spp., *Ptilotus* spp., *Senna* spp. and *Solanum lasiophyllum* open shrubland over *Triodia* spp. open hummock grassland. This was the most abundant habitat type.
- Hilltop, hillslope, ridge or cliff – the vegetation of this fauna habitat typically includes *Eucalyptus leucophloia* and mulga (*Acacia aneura* complex) isolated trees over sparse shrubland of a combination or selection of *Senna artemisioides* subsp. *artemisioides, S. artemisioides* subsp. *filifolia, Ptilotus rotundifolius, Tribulus suberosus, Eremophila fraseri* and *Acacia ancistrocarpa* sparse shrubland to isolated shrubs over *Triodia pungens* hummock grassland. In general this habitat type has a predominantly open character with very little vegetation cover. The slope ranged from minor to very steep, with smaller vegetation cover in the steeper areas.
- Mixed *Acacia* woodland – the vegetation cover on this habitat is typically comprised of open to medium dense woodland with a tree stratum of mulga (*Acacia aneura* complex) and scattered *Acacia pruinocarpa*, over *Acacia maitlandii* and *Ptilotus* sp. sparse shrubland, over *Triodia wiseana* and *T. pungens* open hummock grassland. The habitat was mostly flat with no or very small drainage channels.
- Mulga woodland – this habitat type consists of both groved and banded mulga, where different species of the *Acacia aneura* complex were present in a closed woodland, over *Ptilotus obovatus* and juvenile mulga trees sparse shrubland, over *Maireana* sp. and *Salsola australis* isolated herbs and *Aristida* sp. and *Cymbopogon obtectus* isolated tussock grasses creating distinct micro-habitats that include dense leaf litter and shaded zones. The slope was negligible and this area of habitat was very consistent and with little variation.
- Cracking clay – the cracking clay habitat type supported very few trees and tall shrubs and is characterised by open and sparse low vegetation on clay with approximately half of its area being bare ground.

No habitats recorded were regarded by *ecologia* (2014) as rare or unique to the area.

A total of 23 species of native mammal, two species of introduced mammal, 80 species of bird and 64 species of reptile were recorded during this survey. No species of amphibian were recorded.

A total of 33 invertebrate species from six different Orders were submitted for identification and for Short Range Endemic (**SRE**) status assessment. Fifteen species were identified as potential SRE species. The results of potential SRE specimens submitted comprised the following: four species from two families of spiders (two potential SRE); six species from two families of scorpions (one potential SRE); ten species from two families of isopods (six potential SRE); five species from three families of snails (no SRE), five species from one family of pseudoscorpions (four potential SRE) and three species from three families of millipedes and centipedes (two potential SRE).

## 6.2 FAUNA AND FAUNA HABITATS OF CONSERVATION SIGNIFICANCE

### 6.2.1 Habitats

No habitats recorded were regarded by *ecologia* (2014) as rare or unique to the area. However, the Cracking Clay habitat is considered by Robe to be regionally significant. Mulga woodlands also support a diverse fauna assemblage and are also considered regionally significant. Sites that are likely to be utilised by Ghost Bats for roosting or foraging have moderate conservation significance. The remainder of the fauna habitats are considered to be of low conservation significance, representing units that are likely to be widely distributed and relatively well represented in the region.

### 6.2.2 Vertebrate Fauna

Twenty-one vertebrate fauna species of conservation significance have been identified as potentially occurring in the region: six mammal species; 12 bird species; and three reptile species. A total of six conservation significant species were recorded from the most recent fauna survey, additionally, four species were assessed as having a high likelihood of occurrence with a further four species assessed as having a medium likelihood of occurrence. The remaining seven species were considered to have a low likelihood of occurrence. All of the fauna recorded or assessed as having a high or medium likelihood of occurrence have been previously recorded in the area.

The six conservation significant species recorded in the region consisted of:

- Pilbara Leaf-nosed Bat (*Rhinonicteris aurantius*) listed as 'Vulnerable' under the EPBC Act, as a Schedule 1 species under the state WC Act and as 'Vulnerable' by Parks and Wildlife;
- Fork-tailed Swift (*Apus pacificus*) listed as 'Migratory' under the EPBC Act and as a Schedule 3 species under the WC Act;
- Pilbara Barking Gecko (*Underwoodisaurus seorsus*) listed as P1 species by Parks and Wildlife;
- Australian Bustard (*Ardeotis australis*) listed as P4 species by Parks and Wildlife;
- Western Pebble-mound Mouse (*Pseudomys chapmani*) (secondary evidence only) listed as P4 species by Parks and Wildlife; and
- Bush Stone-curlew (*Burhinus grallarius*) (secondary evidence only), listed as P4 species by Parks and Wildlife.

Additionally, four species of conservation significance were assessed as having a high likelihood of occurrence in the region: Pilbara Olive Python (EPBC Vulnerable, WC Act Schedule 1, Parks and Wildlife Vulnerable); Rainbow Bee-eater (EPBC Migratory, WC Act Schedule 3); Ghost Bat (P4); and Short-tailed Mouse (P4).

The Australian Bustard (*Ardeotis australis*) (P4) was also recorded from the Biota 2005 fauna survey.

Six of the conservation significant species recorded, or assessed as having a high likelihood of occurrence, are considered to be of relevance to the Proposal:

- Fork-tailed Swift (EPBC M, WC Act S3);
- Western Pebble-mound Mouse (P4);
- Short-tailed Mouse (P4);
- Ghost Bat (P4);
- Bush Stone-curlew (P4); and
- Australian Bustard (P4).

The locations of the conservation significant fauna that have been recorded are shown in Figure 6-1.

**Fork-tailed Swift (EPBC M, WC Act S3)**

Seven separate observations of this species were made from five different locations during the *ecologia* (2014) survey. A large flock of 400 birds recorded in conjunction with arriving thunderstorm cloud activity is of note, as this is a significant formation and consistent with the known behaviour of the species. Following the arrival of this large flock, subsequent observations over the coming days consisted of smaller, looser flocks of birds foraging over the landscape. Although this species does not directly utilise habitats, observations were made of Fork-tailed Swifts flying at canopy level, actively hunting aerial insects following the rainfall on the proceeding days. The locations of these further observations were all in low lying habitats (mixed acacia woodland, footslope and plain) within the broad valley floor, suggesting although not directly utilising the habitats within the study area, landform features are still important for foraging activity of this species.

Whilst this species uses the area as foraging habitat, it is highly unlikely that the additional clearing would have any impact on the conservation status of this species.

**Western Pebble-mound Mouse (P4)**

The Western Pebble-mound Mouse, *Pseudomys chapmani* inhabits gently sloping hills of rocky ranges where the ground is stony and vegetated by spinifex and is well known for its behaviour of constructing extensive mounds of small stones. In suitable habitats, pebble mounds of this species can be found in large numbers, although not all of these mounds are active and occupied.

Though listed as P4, the Western Pebble-mound Mouse is common throughout the Pilbara and has been recorded frequently in the region. Several individuals and numerous active mounds were recorded during the 1998 *ecologia* and 2005 Biota surveys in areas of Spinifex Steppe and Mulga Woodland habitat suggesting this species is widespread in the region and persisting despite operations.

Although not trapped during the recent survey, the presence of active mounds for this species suggests the Western Pebble-mound Mouse is likely present within the Proposal area.

The additional clearing is unlikely to impact the conservation status of this species, should it occur, given the occurrences of this species in the locality and the broader bioregion.

**Short-tailed Mouse (P4)**

The Short-tailed Mouse, *Leggadina lakedownensis* occupies a diverse range of habitats, including spinifex and tussock grasslands. The Cracking Clay habitat type is considered to represent ideal habitat for this species within the Pilbara region.

Although not trapped during the recent survey, three records of this species exist in the area from 1997. The previous records of this species within the area along with suitable habitat (Cracking Clay) suggest the Short-tailed Mouse is potentially present within the Proposal area.

The additional clearing is unlikely to impact the conservation status of this species, should it occur, given no impact to the Cracking Clay habitat type is expected.

**Ghost Bat (P4)**

The Ghost Bat, *Macroderma gigas* was not recorded in the recent survey despite the species being known from the locality. This species has been known from West Angelas since at least 1978 (Integrated Environmental Services 1979). The following surveys are applicable to the Proposal:

- a baseline fauna and habitat survey was conducted by *ecologia* during 1998 (*ecologia* 1998a);
- a targeted search for habitats was conducted by *ecologia* in 1998 (*ecologia* 1998c);
- a survey of known habitats was undertaken by *ecologia* in 2000 (*ecologia* 2000);
- a survey of known habitats was undertaken by *ecologia* (*ecologia* 2001);
- a review of survey data was undertaken by Biota in 2002 (Biota 2002);
- a monitoring survey of known habitats was undertaken by Biota in 2003 (Biota 2003);
- a survey of known habitats was undertaken by Biologic Environmental Survey Pty Ltd (Biologic) in 2001 (Biologic 2001);
- a survey of known habitats was undertaken by Biologic in 2012 (Biologic 2012); and
- Biologic most recently conducted a survey of known habitats in 2013 (Biologic 2013, (Appendix 6).

Five caves have been identified as being of value to Ghost Bats: caves A1; A2; L2; and L3 near Deposit B; and a potential maternity cave AA1 near Deposit F. The presence of a potential maternity cave for the Ghost Bat represents the most significant record when considering the environmental significance of the Proposal. The presence of this potential maternity roost could be considered regionally significant, as there are no documented maternity roosts currently known in the area (based on publically available literature).

A Ghost Bat was recorded roosting at cave AA1 during the day and recent scats were also observed in the recent surveys (Biologic 2013).

When the West Angelas Project was assessed in 1997, this species was listed as 'Vulnerable' on the International Union for the Conservation of Nature (**IUCN**) Red List, 'Vulnerable' under Schedule 1 of the *Commonwealth Endangered Species Protection Act 1992* and a Priority Three species under the WC Act. Robe committed to maintain a 100 m barrier to known Ghost Bat roosting caves. The EPA agreed in its Report and Recommendations (EPA 1999) that the West Angelas Project was acceptable provided that the Proponent's commitments were implemented. A Ghost Bat Management Plan was also prepared and implemented in accordance with MS 514. The Plan recognised the potential

maternity cave (AA1) as having particularly high conservation significance and committed to a 200 m exclusion zone.

The Ghost Bat is currently listed as Priority 4 (taxa in need of monitoring) by Parks and Wildlife and remains as 'Vulnerable' on the IUCN Red List. The IUCN (2014) describes its listing as Vulnerable based on the following: small population (numbering less than 10,000 individuals) and in decline. Parks and Wildlife do not provide a justification for the Priority 4 listing, however it is likely attributed to the limited roosting and maternity caves available in the Pilbara, and that much of this habitat is considered to be under threat by mining activities.

Consistent with the current conservation status of this species, Robe proposes to amend the existing environmental management commitment to maintain a 100 m exclusion zone for the potential maternity cave (AA1). A distance of 100 m is considered adequate to protect the integrity of the cave. A 100 m exclusion zone also aligns with the distance proposed in the ERMP (1999), existing management of caves at West Angelas and other Rio Tinto managed operations throughout the Pilbara where caves are required to be protected.

Mining currently occurs close to other environmentally and culturally sensitive sites near Deposits B and E and as such, the operations have an established framework for management of blast vibration to protect the integrity of caves. This framework will continue to be applied to ensure the potential maternity cave (AA1) is not damaged by blast vibration.

**Bush Stone-curlew (P4)**

The Bush stone-curlew (*Burhinus grallarius*) was recorded from secondary evidence only in the most recent survey (*ecologia* 2014), with tracks recorded in Mulga Woodland, which represents suitable habitat for this species. In the region, three additional records exist. This species is likely to occur in low lying habitat areas within micro-habitats of denser grass and shrub vegetation which provides cover for this species to shelter in during the day.

Since Bush Stone-curlews are a ground-dwelling and non-migratory species, they are considered susceptible to local disturbances and to predation (Frith 1976; Johnstone and Storr 1998 in *ecologia* 2014). They are most common where land disturbance is minimal.

The additional clearing is unlikely to impact the conservation status of this species, should it occur, given the mobile nature of the species and the availability of habitat in the locality and the broader bioregion.

**Australian Bustard (P4)**

Though listed as P4, the Australian Bustard, *Ardeotis australis* is moderately common throughout the Pilbara in open or lightly wooded grassland. This species was recorded in the 2005 Biota fauna survey from Mulga communities, which represents suitable habitat for this species.

Although not trapped during the *ecologia* (2014) survey, the previous records of this species within the area along with suitable habitat (Mulga Woodland) suggest the Australian Bustard is potentially present within the Proposal area.

The additional clearing is unlikely to impact the conservation status of this species, should it occur, given the mobile nature of the species and the availability of habitat in the locality and the broader bioregion.

While the presence of other conservation significant species in the area suggests that there is some chance that populations of these species may exist in the area, previous records, combined with the lack of suitable habitat within the Proposal area suggest that their presence is unlikely. Consequently, it is considered highly unlikely that the additional clearing would have an impact on the conservation status of such species.

The additional clearing is not expected to alter the conservation significance of any of the above listed species at either the bioregion or subregion level.

### 6.2.3 Invertebrate Short Range Endemic (SRE) Fauna

Harvey (2002) noted that Short-Range Endemic (**SRE**) species generally possess a series of ecological and life-history traits, including:

- poor powers of dispersal;
- confinement to discontinuous habitats;
- usually highly seasonal, only active during cooler, wetter periods; and
- low levels of fecundity.

As a result, these species have a geographically restricted range, which makes them more vulnerable to changes in conservation status as a result of habitat loss or other threatening processes (EPA 2009). Harvey (2002) defined short range endemism as species having a naturally small range of less than 10,000 km². Within this distribution, the actual areas occupied may be small, discontinuous or fragmented (EPA 2009).

A total of 15 species from the in the most recent survey (*ecologia* 2014) were identified as potential SRE species, comprised of the following: two potential SRE trapdoor spiders; one potential SRE scorpion; four potential SRE pseudoscorpions; six potential SRE isopods; and two potential SRE millipedes / centipedes.

Four of the potential SRE species recorded are considered to be of relevance to the Proposal:

- *Buddelundia* sp. nov. '10 1458A;
- *Urodacus* sp. Indet;
- Olpiidae Genus indet. sp. indet.; and
- *Euryolpium* sp. indet.

Several forms of Mygalomorph spiders (Araneae) were also recorded from the 2005 Biota fauna survey.

**Isopods**

There are currently more than 10,000 described species of isopod however, despite being highly abundant in soil and leaf litter, they are inadequately studied and relatively little is known about the distributions of each species in Australia (Judd et al. 2008). Several species of isopod identified in the Pilbara are known or potential SREs, including *Buddenlundia,* (Judd et al. 2008).

*Buddelundia* sp. Nov. '10 is a species complex and is common and widespread in the Pilbara. There were at least four morphologically different forms found during the *ecologia* (2014) survey. Further work on this group of species is required to understand better their true SRE status.

*Buddelundia* sp. nov. '10 1458A' was the most abundant, with a total of 70 individuals recorded from across the region in a variety of habitats during the *ecologia* (2014) survey.

**Scorpions**

Currently, 23 species of *Urodacus* are described; however, this may represent as little as 20% of the real diversity of this genus in Australia. *Urodacus* appears to be most diverse in Western Australia with few species recorded in eastern Australia. *Urodacus* contains both widespread and SRE species.

A total of 10 unidentifiable females and juveniles of *Urodacus* were collected from across the region in a variety of habitats during the *ecologia* (2014) survey. No adult male specimens were collected and therefore this species is unable to be morphologically identified to species level. Unidentifiable individuals have previously been recorded in the region and were assessed as potential SRE. As *Urodacus* includes range-restricted and widespread species, all unidentified specimens have been considered potential SRE.

**Pseudoscorpions**

The Western Australian pseudoscorpion fauna is fairly diverse with representatives of 17 different families. They are found in a variety of biotopes, but can be most commonly collected from the bark of trees, from the underside of rocks, or from leaf litter habitats (Burger *et al*. 2013)

Three juvenile olpiid pseudoscorpions, recorded from three separate sites across the region in a variety of habitat types during the *ecologia* (2014) survey, could not be identified to genus level because of juvenile life stages. This species has been considered potential SRE due to the taxonomic uncertainty.

A single juvenile from the genus *Euryolpium* was also collected from within the mulga woodland habitat type during the *ecologia* (2014) survey. Due to the juvenile life form of this individual, it cannot be identified to species level. Species of *Euryolpium* are commonly found under bark and under rocks throughout Australia. They can be locally abundant. This specimen has been considered potential SRE due to taxonomic uncertainty.

**Mygalomorph Spiders**

Traditionally, arid and semi-arid areas were considered poor potential habitat for invertebrate fauna given species are often moisture-dependent (Harvey *et al.* 2008 in *ecologia* 2013). Mygalomorphae (trapdoor spiders) are largely considered 'old world' spiders and, as such, are generally adapted to past climatic regimes making them vulnerable to desiccation in arid environments. However, these spiders are burrowing ground-dwellers which often have a trapdoor at the burrow entrance to avoid desiccation.

Due to their habitat specialisation and usually poor powers of dispersal, mygalomorph spiders are frequently identified as SREs despite being a relatively common component of the biota of the Pilbara region.

It is difficult to assess the diversity of mygalomorph species in the Pilbara since the majority of species have not been formally described in the scientific literature. It is also difficult to assess the distribution of mygalomorph species since most species are represented by only a relatively few specimens. Assigning conservation status to species that are unnamed and poorly understood is problematic.

Several forms of mygalomorph spiders were recorded during the 2005 Biota fauna survey. Only mature male mygalomorph spiders can be reliably identified to species level using morphological techniques, and males comprise only approximately 5% of specimens collected, the remaining females and juveniles mostly lack the morphological features that identify species. Therefore, The conservation significance of the mygalomorph spiders that were recorded could not be inferred. The specimens were lodged with the WA Museum. It was intended these specimens would contribute to improved understanding of mygalomorph species found throughout the Pilbara region.

Individuals were recorded in the footslope and plain habitat type, which is the most extensive habitat type within the area.

SRE fauna are particularly vulnerable to potential impacts due to their restricted distributions. The likelihood of the invertebrate species to be considered a SRE was determined based on the current known distribution of each species. Where insufficient or no information was available to determine the SRE status, individuals were assessed as potential SRE. Further research is required to confirm the SRE status of individuals where current knowledge is very limited.

The additional clearing is considered unlikely to impact the conservation status of any species, should it be SRE, given the broad availability of continuous habitat.

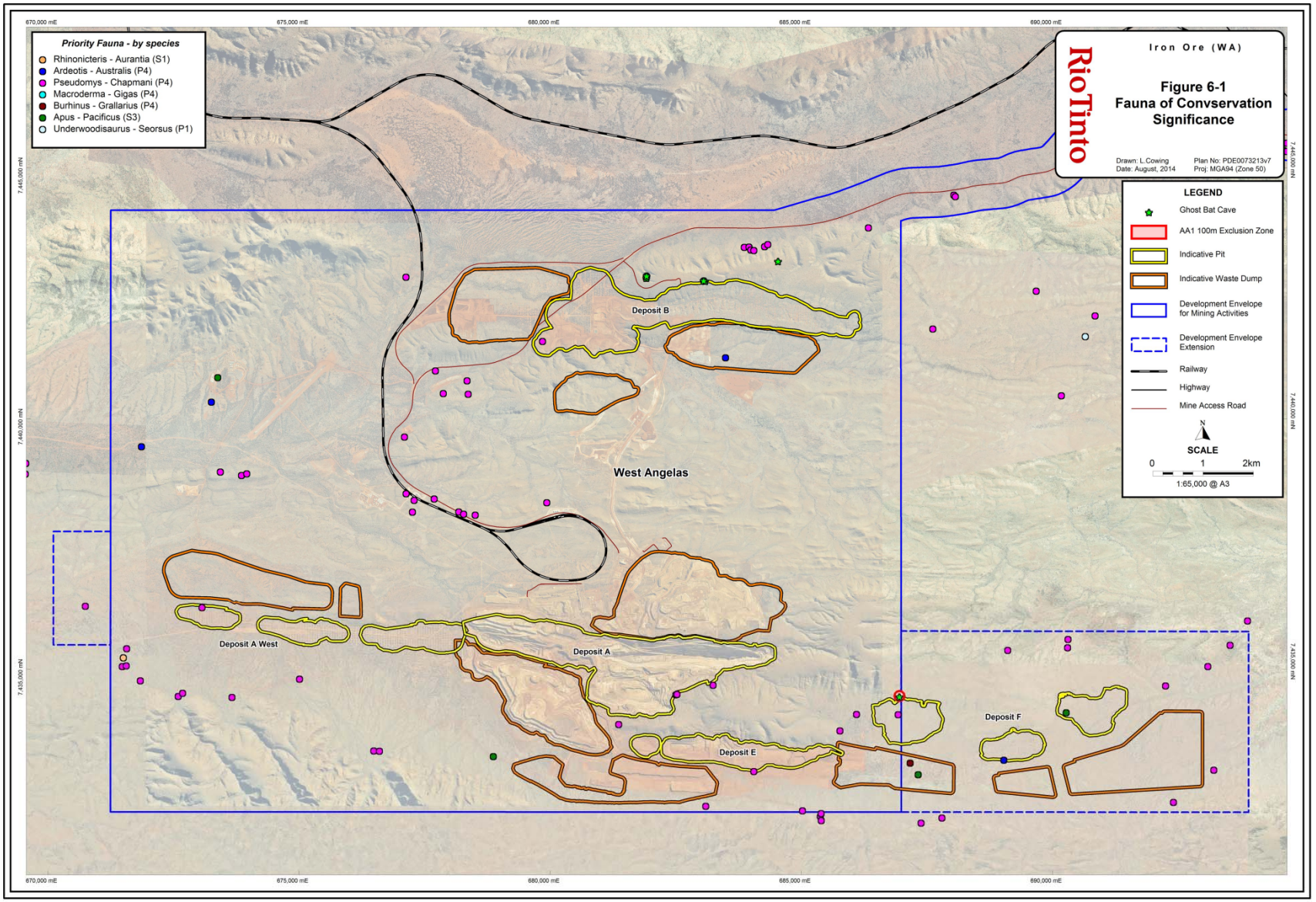



**Figure 6-1: Fauna of Conservation Significance**

**Table 6-2: Terrestrial Fauna: Description of Factor, Impact Assessment and Management**

| EPA Objective | Existing Environment | Potential Impacts (without mitigation) | Management and Outcome |
|---|---|---|---|
| *To maintain representation, diversity, viability and ecological function at the species, population and assemblage level.* | Fauna surveys have been undertaken across the West Angelas region since 1979. *ecologia* recently completed a two-phase vertebrate fauna and terrestrial invertebrate SRE assessment in 2013. A summary of the findings of the surveys that are relevant to the Proposal are provided below.<br>**Conservation Significant Fauna Habitats and Fauna Assemblage**<br>Five of the broad-scale habitat types identified are considered to be of relevance to the Proposal: 'footslope or plain', 'hilltop, hillslope, ridge or cliff', 'mixed acacia woodland', 'mulga woodland' and 'cracking clay'. These habitats are all well represented throughout the subregion.<br>Six conservation significant species recorded or assessed as having a high likelihood of occurrence are considered to be of relevance to the Proposal:<br>• Fork-tailed Swift, *Apus pacificus* (EPBC M, WC Act S3);<br>• Western Pebble-mound Mouse, *Pseudomys chapmani* (P4);<br>• Short-tailed Mouse, *Leggadina lakedownensis* (P4);<br>• Ghost Bat, *Macroderma gigas* (P4);<br>• Bush Stone-curlew, *Burhinus grallarius* (P4); and<br>• Australian Bustard, *Ardeotis australis* (P4).<br>The location of conservation fauna that have been recorded are shown in Figure 6-1.<br>Five of the potential SRE species recorded are also considered to be of relevance to the Proposal; one species of isopod, one species of scorpion, two species of pseudoscorpion and one species of spider.<br>The two fauna assessment reports relevant to the Proposal are provided as Appendix 5 and Appendix 6. | **Clearing of fauna habitat**<br>The Proposal will result in the clearing of up to 3,220 ha of potential fauna habitat (in addition to the 4,667 ha approved under MS 970), therefore habitat loss is likely to continue to be the biggest threat to fauna, including several conservation significant fauna species (namely: Fork-tailed Swift, the Western Pebble-mound Mouse, the Short-tailed Mouse, the Ghost Bat, the Bush Stone-curlew and the Australian Bustard) as well as five potential SRE species.<br>Given their potential to be restricted at small spatial scales, SRE species are generally at greater risk of changes in conservation status or local population extinctions than other, more widely distributed fauna. This risk can be increased by threatening processes including clearing of habitat (EPA 2009). However, the additional clearing is unlikely to impact the conservation status of the potential SRE species given the broad availability of continuous habitat for these species.<br>The presence of the Ghost Bat represents the most significant faunal finding to the overall environmental value of the Proposal area. Populations of this species are known from a series of roost caves in the region including the potential maternity cave (AA1 near Deposit F). Robe commits to maintain a 100 m exclusion zone for the potential maternity cave (AA1) and will also continue to apply the established framework for management of blast vibration to protect the integrity of cave.<br>The potential impacts to fauna populations (including potential SRE species) from the Proposal are considered to remain unchanged from that assessed in the ERMP, given the proposed changes in this Proposal will:<br>• Not affect regional population levels of any fauna species (including potential SRE species).<br>• Not affect any new fauna species (including potential SRE species) or habitat types that have not been previously assessed.<br>• Not contribute a new or additional threat to conservation significant fauna species (including potential SRE species). | The key potential impact of the Proposal on terrestrial fauna (including potential SRE species); clearing of fauna habitat will be minimised via management measures to reduce potential impacts on flora and vegetation, as detailed in Table 5-3.<br>Habitat degradation as a result of hydrological changes will be minimised via management measures to reduce potential impacts on natural hydrological regimes, as detailed in Table 7-1.<br>In addition, the following key management measures from the Environmental Management Program (Appendix 7) have been, and will continue to be, implemented to manage potential impacts on fauna:<br>• Clearing has, and will continue to, avoid significant fauna habitats as far as practicable.<br>• Sites that are utilised by Ghost Bats have, and will continue to be, avoided as far as practicable.<br>• Buffers around sites that are utilised by Ghost Bats have, and will continue to be, demarcated and maintained, where practicable, to a minimum of 100 m.<br>• Cave AA1 is considered to be of high conservation significance and therefore this buffer will be a minimum of 100 m.<br>• Blast vibration control, including vibration risk assessment, controlled blasting and vibration monitoring has been, and will continue to be, implemented for blasts in proximity of sites that are utilised by Ghost Bats.<br>• Appropriate signage has, and will continue to be, put in place at sites that are utilised by Ghost Bats.<br>• The use of barbed wire fences is prohibited, unless a statutory requirement (e.g. Electricity (Licensing) Regulations 1991). Where barbed wire is necessary, reflectors will be installed to deter bats.<br>• Vehicles have, and will continue to be, restricted to designated tracks and drivers will abide by the allocated speed limit except in cases of emergency.<br>• Known native fauna 'hot spots' will be sign posted to notify drivers.<br>• The requirements of the Wildlife Interaction Policy will be communicated to, and implemented by, all personnel.<br>• Native animals encountered on-site will be given the opportunity to move on if there is no threat to personnel safety in doing so.<br>• Snakes will be relocated from work areas by appropriately trained snake-handlers.<br>• If sick or injured animals are encountered, a nominated carer will assess possible rescue and rehabilitation of the animal.<br>• Dead ghost bats will be lodged with the Western Australian Museum. |

| EPA Objective | Existing Environment | Potential Impacts (without mitigation) | Management and Outcome |
|---|---|---|---|
| | | | • Feral animal control Feral animal control measures will be implemented, including:<br>  • prohibiting the feeding of feral animals;<br>  • trapping and eradication programs; and<br>  • effective management of domestic waste.<br>**Outcome**<br>The Revised Proposal can be managed to meet the EPA objective for this factor, in summary:<br>• Fauna habitats potentially impacted by the Proposal, including habitat of higher value for conservation significant fauna species, are well represented outside of the Proposal area on a local and regional scale.<br>• Appropriate management measures to avoid, minimise and mitigate potential impacts of the Proposal on fauna and fauna habitats have been, and will continue to be implemented. |

# 7 HYDROLOGICAL PROCESSES (SURFACE WATER)

This Section describes the hydrological systems that exist within the West Angelas region, provides details regarding the potential impacts to surface water regimes and the surface water management strategy that forms part of this Proposal.

The EPA applies the following objective from EAG 8 in its assessment of proposals that may affect hydrological processes:

> *To maintain the hydrological regimes of groundwater and surface water so that the existing and potential uses, including ecosystem maintenance, are protected*

Table 7-1 describes how the proposal meets the EPA's objectives in respect of Hydrological Processes and Inland Water Environmental Quality (Surface Water).

## 7.1 REGIONAL HYDROLOGY

Deposits A, A west, B, E and the majority of Deposit F (pits F1 and F2) are located within the upper reaches of the Turee Creek East catchment which forms part of the regional Ashburton River Catchment. The upper catchment has a complex drainage pattern characterised by intermittent flow and infrequent wide-spread flooding, depending on the occurrence of high intensity rainfall events. Turee Creek East represents the most significant named watercourse in the area with a catchment area of approximately 2,050 km².

The F3 orebody, part of Deposit F, is located in the upper reaches of the Weeli Wolli Creek catchment, part of the regional Upper Fortescue River catchment, immediately west of the regional Ashburton River catchment. The Weeli Wolli Creek catchment covers an area of approximately 3,991 km². Weeli Wolli Creek flows in a north easterly direction and merges with Marillana Creek 60 km downstream from Deposit F.

## 7.2 LOCAL HYDROLOGY

The topography consists of a range of steep hills extending in an east – west direction to the south of both Deposit A west and Deposit F. The hills are characterised by steep incised drainage channels. However as the channels extend out from the hillside to the very flat valley floor, they transform into shallow, poorly defined drainage lines typical of overland flow depending on the occurrence of high rainfall events. The location and extent of these shallow drainage lines on the valley floor are often hard to define.

Deposit A west sits within the valley floor of a tributary of Turee Creek East. Figure 7-1 illustrates local catchments contributing to Deposit A west. All flows intercepted by the proposed pits naturally flow in a northerly direction. The total catchment area intercepted by the proposed A west pits is approximately 23 km².

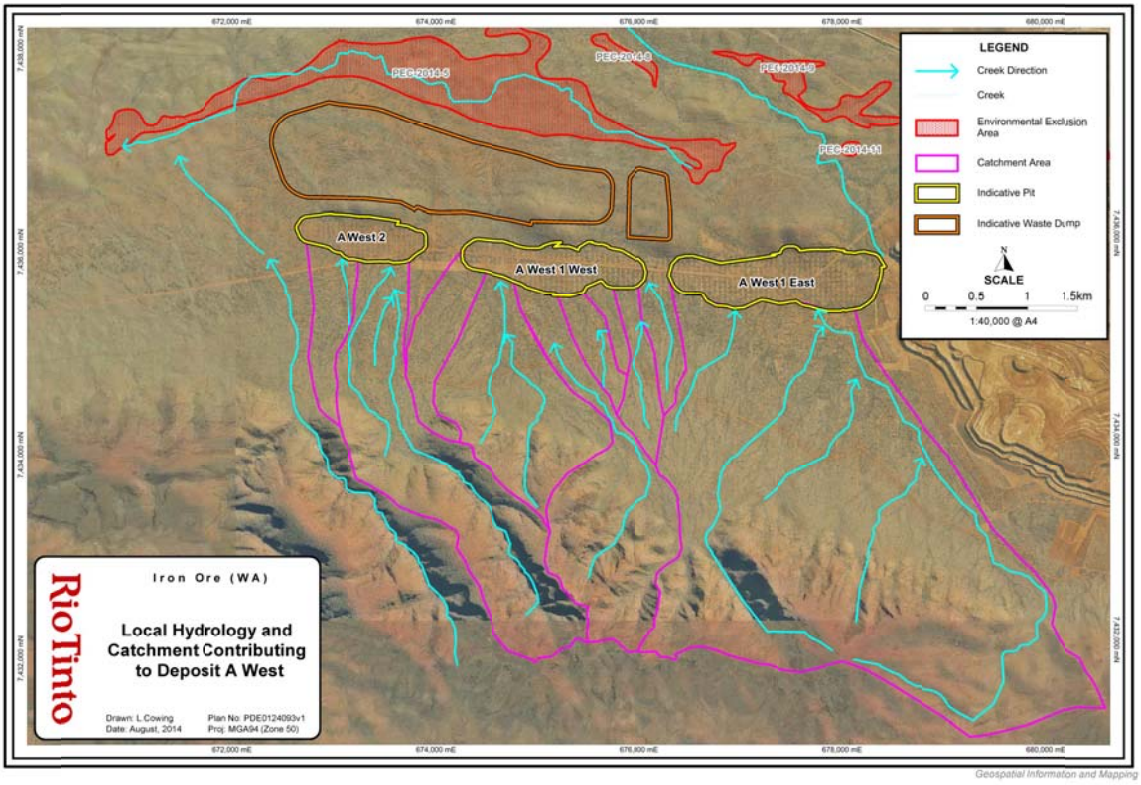



**Figure 7-1: Local hydrology and catchment contributing to Deposit A west.**

Deposit F is located on the Turee Creek East and Weeli Wolli Creek catchment divide. Pits F1 and F2 are situated within the same valley as Deposit E, extending from the valley floor into the hills to the north. An ephemeral unnamed tributary, hereafter referred to as central creek, rises in the hills to the southeast of Deposit F. Prior to any development at West Angelas, central creek naturally flowed to the west along the valley floor, naturally crossing Deposit F, pit F2 and Deposit E and then meandered north westerly across Deposit A. Currently, central creek is intercepted immediately upstream of Deposit E.

A large number of relatively small local catchments are intercepted by Deposit F. The total catchment area intercepted by the proposed Deposit F pits is approximately 15 km² (1 $km^2$, 13 $km^2$ and 1$km^2$ for pits F1, F2 and F3 respectively). Figure 7-2 illustrates local catchments contributing to Deposit F.

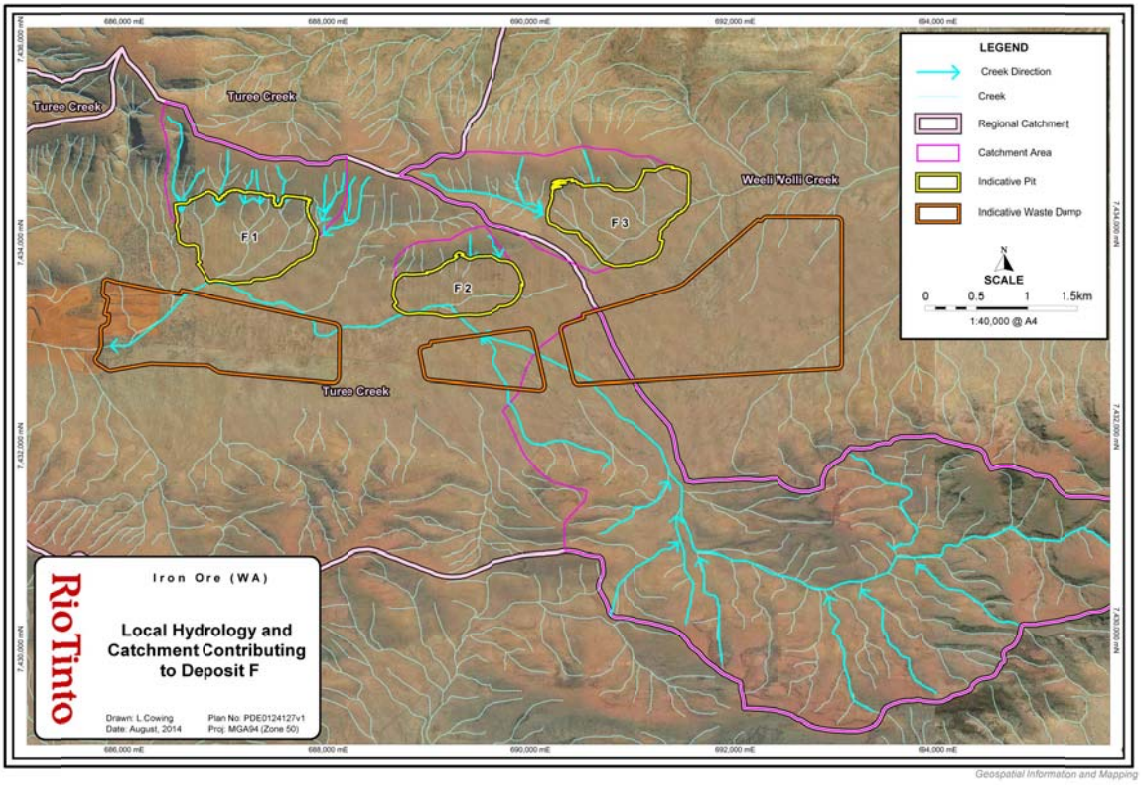



**Figure 7-2: Local hydrology and catchment contributing to Deposit F**

## 7.3 HYDRAULIC MODELLING

In order to assess the characteristics of the surface water flow regime across the valley floor in proximity of Deposit A west and Deposit F, a hydraulic model was developed. The model results replicate what has been observed in the field. The drainage channels are clearly defined in the hills. As the channels extend out from the hills into the valley floor they become very shallow and difficult to define. The flow in the valley floor is thought to be predominately overland flow rather than channelised flow, i.e. very wide in extent and shallow in depth. Flow of this type is sensitive to changes in the local topography.

## 7.4 SURFACE WATER MANGEMENT

MS 970 contains the following Conditions relevant to surface water management:

**7 Surface Water Drainage**

7-1 The proponent shall manage surface water drainage and discharge to ensure minimal adverse impacts on existing surface water drainage patterns or the water dependent ecosystems.

7-2 To verify that the requirements of condition 7-1 are met, the proponent shall undertake monitoring as outlined in the Surface Water Management Plan approved as part of the Environmental Management Program required by condition 5.

7-3 In the event that the monitoring required by condition 7-2 indicates that the requirements of condition 7-1 are not met, the proponent shall implement contingency actions as outlined in the Surface Water Management Plan.

7-4 The proponent shall submit annually the results of monitoring required by condition 7-2 to the CEO as part of the Compliance Assessment Reports required by condition 3-6.

It is intended that Deposits A west and F will be managed in accordance with these existing conditions. To meet the requirements of these conditions, several surface water management strategies have been investigated. The preferred strategies are outlined below.

**Deposit A west**

To manage the 23 km² of catchment intercepted by the proposed Deposit A west, a 5% Annual Exceedance Probability (**AEP**) capacity diversion channel is proposed to the south of the pits. The diversion channel will capture runoff from the local catchment and redirect it westwards, releasing the water into a local tributary that results in the continuation of flow along its natural path.

Three scenarios were modelled to assess changes to the hydrologic regime during rainfall events: Scenario 1 - current conditions; Scenario 2 - 5% AEP capacity diversion channel; and Scenario 3 - no diversion channel. Flows were assessed for all three scenarios at two locations approximately 7.5 km downstream (**PO1**) and 13 km downstream (**PO2**) of A west respectively (Figure 7-3 and Figure 7-4). Modelling indicates peak flows in both locations are unaffected under Scenario 2.

Scenario 2 results in a slightly higher secondary peak at PO1 as runoff from the A west catchment area is travelling a more direct path via the diversion channel rather than its natural meandering path. Fifteen percent volume is lost due to intercepted rainfall; however more volume is retained than in Scenario 3 where 30% volume is lost. This scenario results in the total loss of the secondary peak as all runoff is intercepted.

Limited hydrological impact is visible at PO2.

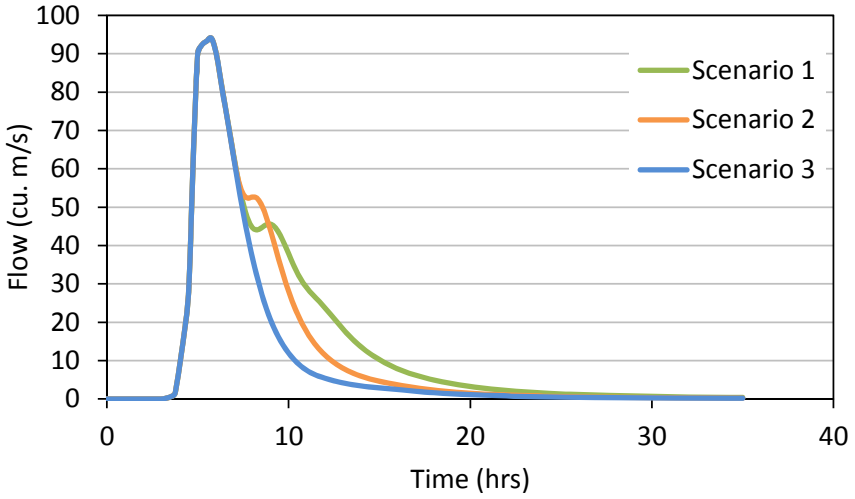



**Figure 7-3: Hydrographs at PO1 approximately 7.5 km downstream of A west**

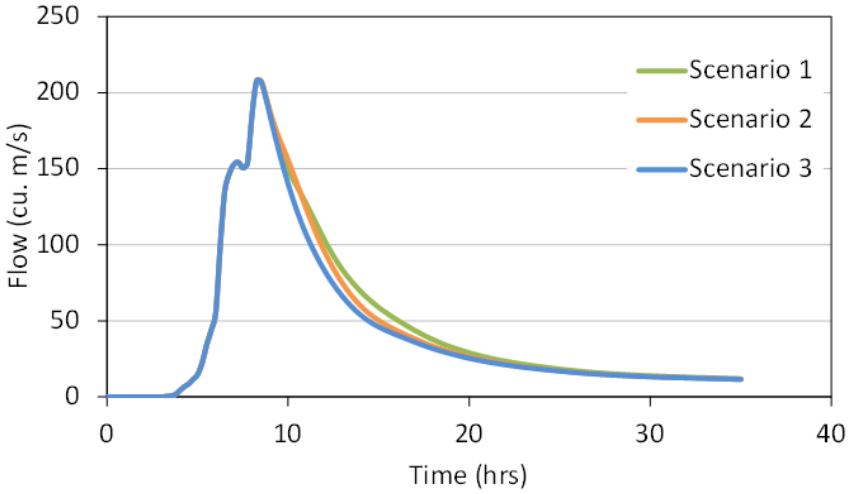



**Figure 7-4: Hydrographs at PO2 approximately 13 km downstream of A west.**

The proposed A west diversion results in the maintenance of natural flows.

**Deposit F**

Surface water management options around Deposit F are limited due to the valley topography. The surface water management options are being considered for Deposit F are as follows:

- Passive – Pits F1 and F3 intercept approximately 1 km² of local catchment each. A passive surface water management strategy is proposed for these deposits under which local runoff intercepted by the pits will be allowed to naturally terminate in the pits.
- 2% AEP Diversion – The proposed development of pit F2 will intercept central creek. A 2% AEP capacity diversion channel is proposed to divert the creek upstream of pit F2 eastwards across the catchment divide to facilitate continued flow. No viable alternative option was identified that could continue the flow within its natural catchment.

  The central creek catchment at this location is approximately 12 km². The receiving catchment, Weeli Wolli, has a total catchment area of 3,991 km². It is therefore considered that the proposed additional catchment contribution (0.3%) is negligible in the context of the total area of the receiving catchment.

  Two scenarios were modelled to assess changes to the hydrologic regime within the receiving catchment during rainfall events: Scenario 1 - current conditions and Scenario 2 - diversion channel. Flows were assessed for both scenarios at three locations approximately 15 km downstream (**PO3**), 25 km downstream (**PO4**) and 30 km downstream (**PO5**) of pit F2 respectively. Modelling indicates peak flows, and therefore maximum extent of the flow is only marginally altered under Scenario 2 and this impact diminishes with increasing distance downstream. No increase in peak flow is expected at PO5, 30 km downstream, in events up to a 20% AEP.

  Water depth difference mapping was also undertaken to understand the change in expected water depth from current condition. From approximately 8 km downstream of the diversion channel there is a negligible change in depth. It is therefore considered that the proposed additional catchment contribution will have a negligible effect on the natural hydrological regime of the receiving Weeli Wolli catchment.

Additionally, surface water runoff in the region is only associated with high intensity rainfall events. As is common across the Pilbara region, annual rainfall at West Angelas is highly variable and rainfall events resulting in surface water flows are uncommon. Based on rainfall data for the area and flow analysis in the Weeli Wolli catchment, rainfall events that result in flow have a less than 1% probability of occurrence annually.

The catchment contributing to central creek has been progressively reduced due to mining at Deposits A and E and would continue to be reduced by mining at Deposit F. The proposed diversion of central creek upstream of pit F2 eastwards across the catchment divide will terminate the flow of this creek in its original catchment, facilitating management of surface water flows for all deposits that intercept central creek. Flows in central creek are expected to continue to be artificially maintained downstream of operations by the continued discharge of surplus water.

## 7.5 KEY ENVIRONMENTAL RECEPTORS

### West Angelas Cracking Clay PEC

The West Angelas Cracking Clay PEC occurs extensively within the area on relatively flat valley floors. Three small hills separate the Clacking Clay PEC from Deposit A west.

Under existing conditions, flow from rainfall events spreads across the valley floor in shallow, broad channels. These shallow channels do not cover the entire extent of the Cracking Clay PEC. 2D hydraulic modelling was undertaken to understand the interactions between the Cracking Clay PEC and patterns of surface water flow in the area.

Based on the modelling, three inflow paths from the southern catchments cross the Cracking Clay PEC (CC1, CC2 and CC3) (Figure 7-5). These flow paths will be intercepted by Deposit A west so they were examined to further understand the interaction between the Cracking Clay PEC and the southern catchment.

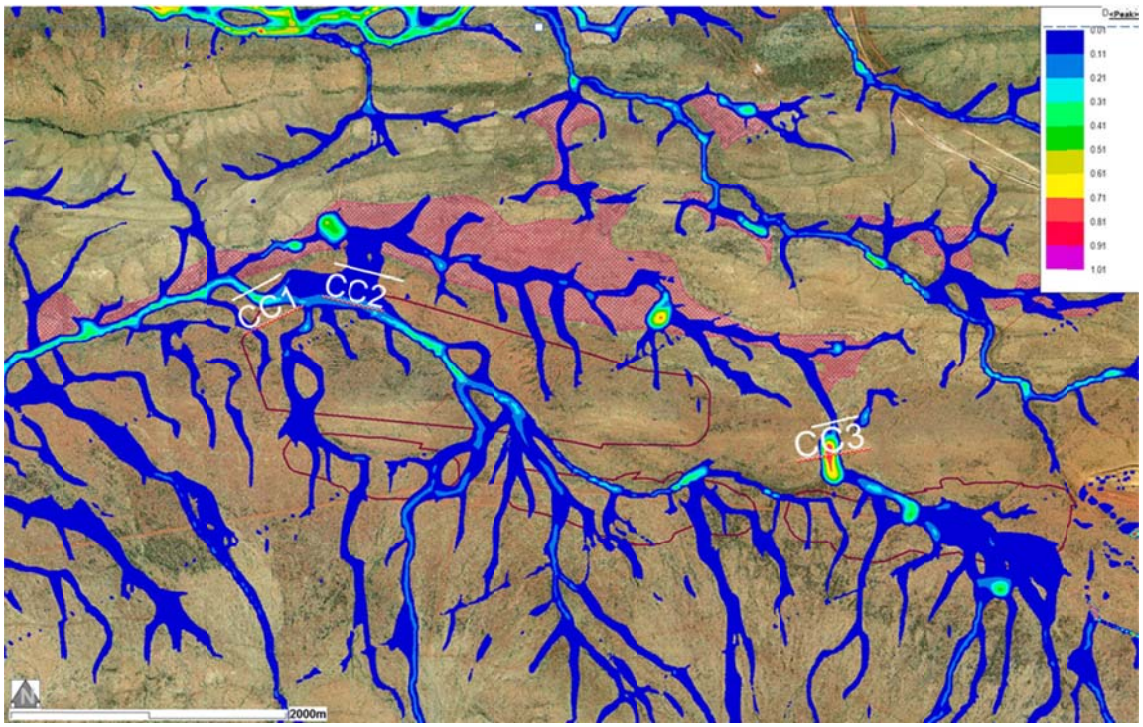



**Figure 7-5: Peak flow depths in the Cracking Clay PEC during a 20% AEP event.**

It is evident from the 20% AEP hydrographs that inflows at two of the three channels, CC2 and CC3, are insignificant (Figure 7-6). CC1 is the main channelised inflow source in contact with the Cracking Clay PEC. This inflow channel only interacts with the small western portion of the Cracking Clay PEC, representing less than 1% of the total extent of the community. The 20% AEP event is examined as events greater than a 20% AEP are considered too infrequent to sustain vegetation. The modelling therefore indicates that channelised flow only interacts with the Cracking Clay PEC during large, infrequent flow events. Incident rainfall and overland flow from local catchments are considered to be the significant hydrological factors in sustaining the Cracking Clay PEC.

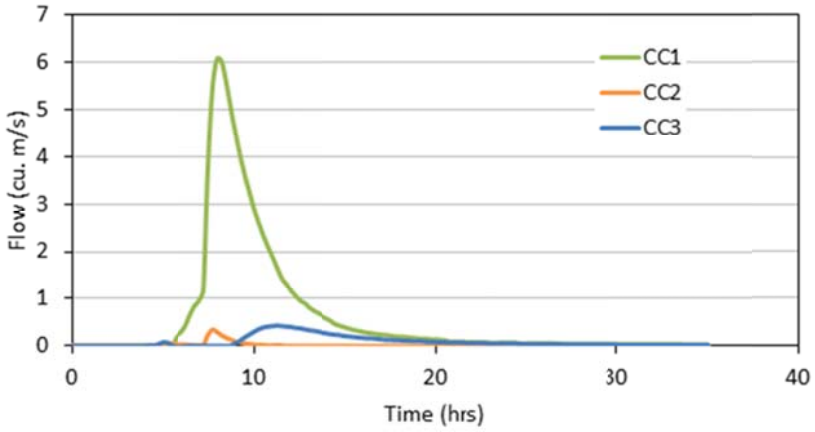



**Figure 7-6: Hydrographs at inflow channels CC1, CC2 and CC3.**

The condition of the Cracking Clay PEC has previously been described as poor following a number of years of below average rainfall. The Cracking Clay PEC appears to be sustained by incident rainfall and local catchment runoff from the surrounding hills and therefore, it is considered that the Cracking Clay PEC would not be detrimentally impacted by the Proposal.

### Valley floor mulga

Valley floor mulga (previously *Acacia aneura* but now including a number of species) are widely recognised as being dependent on patterns of surface water flow.

Deposits A west and F intercept a number of flow paths from the surrounding catchments. However, valley floor mulga is dependent upon shallow overland flow rather than channelised flow.

Valley floor mulga communities will continue to be sustained by incident rainfall and overland flow following rainfall events and therefore, it is considered that the valley floor mulga would not be detrimentally impacted by the Proposal.

**Table 7-1: Hydrological Processes (Surface Water): Description of Factor, Impact Assessment and Management**

| EPA Objective | Existing Environment | Potential Impacts (without mitigation) | Management and Outcome |
|---|---|---|---|
| *To maintain hydrological regimes of surface water so that existing and potential uses, including ecosystem maintenance, are protected.* | **Surface water flows**<br><br>Deposits A, A west, B, E and the majority of Deposit F (pits F1 and F2) are located within the Turee Creek East catchment. The F3 orebody is located within the upper reaches of the Weeli Wolli Creek catchment.<br><br>Deposit A west intercepts approximately 23 km² of local catchment. A 5% AEP capacity diversion channel is proposed to the south of the pits to capture the runoff from the local catchment and redirect it westwards maintaining natural flows.<br><br>Deposit F, Pits F1 and F3 intercept approximately 1 km² of local catchment each. A passive surface water management strategy is proposed for pits F1 and F3 under which local runoff intercepted by the pits will be allowed to naturally terminate in these pits.<br><br>Deposit F, Pit F2 naturally intercepts an unnamed tributary with a 12 km² catchment. A 2% AEP capacity diversion channel is proposed to divert the creek upstream of the F2 pit eastwards across the catchment divide into the adjacent Weeli Wolli catchment. No viable alternative option exists to continue the flow of this creek within its natural catchment.<br><br>Flows in central creek are expected to continue to be artificially maintained downstream of operations by the continued discharge of surplus water.<br><br>**Key environmental receptors**<br><br>The West Angelas Cracking Clay PEC and valley floor mulga communities occur extensively throughout the area. Both of these communities are recognised as being dependent on patterns of surface water flow. | **Diversion of surface water flows**<br><br>The Proposal will result in the diversion of natural surface water flows, however; no potential impacts are expected given that:<br><br>• The Deposit A west diversion will result in the maintenance of natural flows.<br><br>• The Deposit F diversion will result in the maintenance of flows in the adjacent catchment. It is considered that the proposed additional catchment contribution from the Deposit F diversion will have a negligible effect on the natural hydrological regime of the receiving catchment.<br><br>**Altered hydrological regime**<br><br>Some changes to the hydrologic regime are expected however; modelling indicates that the Cracking Clay PEC and valley floor mulga communities would not be detrimentally impacted by altered hydrological regimes. | The following key management measure from the Environmental Management Program (Appendix 7) has been, and will continue to be, implemented to manage potential impacts on hydrological processes and inland water environmental quality of surface water:<br><br>• Surface water flows that are intercepted by operations have, and will continue to be diverted to maintain natural flows as far as practicable.<br><br>Where it is not possible to continue flow within its natural catchment, surface water flows will be diverted to facilitate continued flow in the adjacent catchment. The proposed diversion will have a negligible effect on the natural hydrological regime of the receiving catchment.<br><br>Surface water quality management is included within the Environmental Management Program which will continue to be implemented.<br><br>**Outcome:**<br><br>The Revised Proposal can be managed to meet the EPA objective for this factor, in summary:<br><br>• Appropriate management measures to avoid, minimise and mitigate potential impacts of the Proposal on surface water flows have been, and will continue to be, implemented.<br><br>• Impacts to surface water flows will be localised, there will be no significant impacts on regional surface water and no impacts on key environmental receptors. |

# 8 REHABILITATION AND CLOSURE

The EPA applies the following objective from EAG 8 in its assessment of proposals:

> *To ensure that premises can be closed, decommissioned and rehabilitated in an ecologically sustainable manner, consistent with agreed outcomes and land uses, and without unacceptable liability to the State.*

MS 970, which was issued for the West Angelas Iron Ore Project in June 2014, contains the following Conditions relevant to closure:

**9 Rehabilitation and Closure**

9-1 The proponent shall ensure that the mine is closed, decommissioned and rehabilitated in an ecologically sustainable manner, consistent with agreed post-mining outcomes and land uses, and without unacceptable liability to the State of Western Australia.

9-2 The proponent shall prepare a Mine Closure Plan for the West Angelas Iron Ore Project.

9-3 The Mine Closure Plan required by condition 9-2 shall:

(1) when implemented, manage the implementation of the proposal to meet the requirements of condition 9-1;

(2) be prepared in accordance with the *Guidelines for Preparing Mine Closure Plans, June 2011* (Department of Mines and Petroleum and Environmental Protection Authority) or its revisions; and

(3) be to the requirements of the CEO on advice of the Department of Mines and Petroleum.

9-4 Within 12 months of commissioning of additional mine pits or as otherwise agreed by the CEO the proponent shall implement the approved Mine Closure Plan and continue implementation until otherwise agreed by the CEO.

9-5 Revisions to the Mine Closure Plan may be approved by the CEO on the advice of the Department of Mines and Petroleum.

9-6 The proponent shall implement revisions of the Mine Closure Plan required by condition 9-5.

Additionally, the EPA expects closure plans to be submitted with the approvals documentation to facilitate the incorporation of closure issues into its environmental impact assessment.

The West Angelas Closure Plan has been developed to address closure of existing Deposits A, B and E as well as Deposits A west and F, the subject of this Proposal (Appendix 8). This Closure Plan follows the format and content requirements for mine closure plans as recommended by the Office of the Environmental Protection Authority / Department of Mines and Petroleum (**DMP**) *Guidelines for Preparing Mine Closure Plans*.

## 8.1 POST MINING LAND USE

Options for post-mining land use are limited, with mining and pastoralism the only industries that have historically proven viable. The only land use options under consideration for West Angelas are a change to pastoralism or establishment of a native ecosystem. These options are differentiated by the vegetation communities proposed to be returned on closure (Table 8-1).

**Table 8-1: Post mining land use options under consideration for West Angelas**

| Land use option | Differentiating Factors |
|---|---|
| Pastoralism | *Rehabilitate to facilitate sustainable pastoral land use*.<br>Vegetation includes non-native species desired for rangeland cattle production; and<br>Infrastructure left in place to support pastoral activities. |
| Native ecosystem | *Rehabilitate to maintain or foster regional biodiversity:*<br>Vegetated with species of local provenance; and<br>Revegetation planning considers establishment of multiple habitat types. |

## 8.2 CLOSURE OBJECTIVES AND COMPLETION CRITERIA

Closure objectives reflect key issues against which closure performance will be assessed by regulators. The following closure objectives have been agreed for West Angelas:

- minimise the long term visual impact by reshaping the land so it is compatible with the adjacent landscapes;
- re-establish self-sustaining ecosystems;
- ensure no changes to groundwater quality through evaporation; and
- address public safety hazards.

These closure objectives were established through the original environmental assessment processes prior to the commencement of mining. The objective to “address public safety hazards” has been added to the original objectives list to reflect the Proponents commitment to managing safety.

Indicative completion criteria have been proposed within the Closure Plan (Appendix 8).

## 8.3 ANTICIPATED CLOSURE OUTCOMES

The shape of the landscape at West Angelas is still evolving, with the final mine void areas and waste dump locations and dimensions still in development across all of the deposits.

Based on the current plan, the post mining landform will consist of nine separate voids which have been partially backfilled during operations to varying levels. The voids may require further backfill post operations to prevent the post-closure exposure of the groundwater table.

On closure of the mine, groundwater levels are expected to recover to slightly lower than pre-mining levels, without affecting local or regional groundwater quality. The backfill strategy has been adopted to prevent the formation of permanent pit lakes. It is recognised that ephemeral lakes may form at the base of the voids following rainfall events and higher than average rainfall years. It is expected that these will dissipate naturally during the following dry season. Although the quality of these lakes may deteriorate, they are not expected to affect local or regional groundwater quality.

It has been observed in other groundwater modelling studies that the creation of a pit lake that acts as a groundwater sink can have limited impact on the surrounding groundwater quality, as the salts are largely trapped within the lake. However, it is recognised that the creation of a pit lake can raise social concerns and have other environmental impacts. Further investigations and discussions with stakeholders are required to determine if pit lakes can provide an acceptable closure alternative at West Angelas.

In general, pit walls are not designed to be stable in perpetuity. The area around the pits will be unstable, and the pit walls are expected to collapse over time. However, caves containing important environmental and cultural features will remain outside of this zone of instability, and be left undisturbed.

Several waste dumps will remain external to the voids. The waste dumps and other disturbance areas across the site will be shaped to create stable landforms and vegetated with native species of local provenance. There is opportunity to identify areas that may be rehabilitated to replicate habitats of high value.

Local hydrological regimes have been and will continue to be substantially altered. It is not intended that diverted creeks be restored as part of the closure strategy. Surface water management structures that have been or will be built to be retained on closure include:

- the diversion berm and drainage channel used to divert surface water flows from an unnamed tributary to protect Deposit B;
- the proposed diversion berm that will re-direct sheet flow from Deposit A west; and
- the proposed diversion berm and drainage channel used to divert surface water flows from an unnamed tributary to the adjacent catchment to protect Deposit F.

**Table 8-2: Rehabilitation and Closure: Description of Factor, Impact Assessment and Management**

| EPA Objective | Existing Environment | Potential Impacts (without mitigation) | Management and Outcome |
|---|---|---|---|
| *To ensure that premises can be closed, decommissioned and rehabilitated in an ecologically sustainable manner, consistent with agreed outcomes and land uses, and without unacceptable liability to the State.* | The West Angelas Closure Plan has been developed to address closure of existing Deposits A, B and E as well as A west and F.<br><br>Based on the current plan, the post mining landform will consist of nine separate mine voids which have been partially backfilled during operations to varying levels to prevent post-closure exposure of the groundwater table.<br><br>Several waste dumps will remain external to the voids. The waste dumps and other disturbance areas across the site will be shaped to create stable landforms and vegetated with native species of local provenance.<br><br>Local hydrological regimes have been and will continue to be substantially altered. It is not intended that diverted creeks be restored as part of the closure strategy. Surface water management structures that have been or will be built to be retained on closure include:<br>• the diversion berm and drainage channel used to divert surface water flows from an unnamed tributary to protect Deposit B;<br>• the proposed diversion berm that will re-direct sheet flow from Deposit A west; and<br>• the proposed diversion berm and drainage channel used to divert surface water flows from an unnamed tributary to the adjacent catchment to protect Deposit F. | On closure of the mine, groundwater levels are expected to recover to slightly lower than pre-mining levels, without affecting local or regional groundwater quality.<br><br>The backfill strategy has been adopted to prevent the formation of permanent pit lakes. It is recognised that ephemeral lakes may form at the base of the voids following rainfall events and higher than average rainfall years. It is expected that these will dissipate naturally during the following dry season. Although the quality of these lakes may deteriorate, they are not expected to affecting local or regional groundwater quality.<br><br>The Acid and Metalliferous Drainage (**AMD**) assessment concluded that the risk of AMD being generated from all deposits is low. A broader assessment of AMD is discussed in Section 9. | West Angelas is subject to Condition 9 of MS 970 which requires the Proponent to prepare a Mine Closure Plan to 'ensure that the mine is closed, decommissioned and rehabilitated in an ecologically sustainable manner, consistent with agreed post-mining outcomes and land uses, and without unacceptable liability to the State of Western Australia'.<br><br>The West Angelas Closure Plan has been developed to address closure of existing Deposits A, B and E as well as A west and F (Appendix 8) in accordance with Condition 9 of MS 970.<br><br>The Closure Plan documents the current closure knowledge base for West Angelas. It outlines the objectives that need to be met at closure, the strategies and plans to be employed to achieve them, and provides an indication of the criteria that will be used to assess closure success.<br><br>The Closure Plan is not a static document. Robe will continue to revisit the Closure Plan on a regular basis to ensure that the objectives to which it is working towards remain relevant and aligned to stakeholder expectations, and to revise its strategies and plans where appropriate to achieve improved closure outcomes.<br><br>**Outcome**<br><br>The Revised Proposal can be managed to meet the EPA objective for this factor, in summary:<br>• Closure planning has been, and will continue to be, implemented to ensure that the West Angelas Revised Proposal can be closed in an ecologically sustainable manner, consistent with agreed outcomes and land uses.<br>• It is expected that the post-closure groundwater table will recover to a point below the pre-mining water table without affecting local and regional groundwater quality. |

# 9 OTHER ENVIRONMENTAL FACTORS

As discussed in Section 4 the Key Environmental Factors of this Proposal are Flora and Vegetation (refer to Section 5); Terrestrial Fauna (refer to Section 6); Hydrological Processes and Inland Water Environmental Quality (Surface Water) (refer to Section 7); and Rehabilitation and Closure (refer to Section 8).

Table 9-1 outlines environmental factors that were not considered in this Environmental Review as the Proposal, if implemented, will not result in any significant change in addition to or different from that originally assessed and approved under MS 970.

**Table 9-1: Factors Considered Not Relevant to this Proposal**

| Factor | EPA Objective | Description of Factor | Impacts | Existing Management and Mitigation Measures |
|---|---|---|---|---|
| Subterranean Fauna | *To maintain representation, diversity, viability and ecological function at the species, population and assemblage level.* | Subterranean fauna surveys have been undertaken over the entire West Angelas area since 1979. The following surveys are applicable to the Proposal;<br>• a baseline survey was conducted by ecologia during 1998 (*ecologia* 1998b);<br>• a monitoring survey was undertaken by ecologia in 2002 (*ecologia* 2002);<br>• a monitoring survey was undertaken by Biota in 2003 (Biota 2003);<br>• a baseline survey of Deposits E and F was conducted by Biota in 2004 (Biota 2004b);<br>• a monitoring survey was undertaken by Biota in 2008 (Biota 2008);<br>• a monitoring survey was undertaken by Biota in 2012 (Biota 2012); and<br>• a subterranean fauna assessment survey was undertaken by *ecologia* in 2013.<br>The occurrence and distribution of subterranean fauna is influenced or limited by the geological formation in which they occur. Such dispersal limitations result in extremely small, fragmented species ranges and thus high levels of endemism (EPA 2003). In order to assess the potential for subterranean fauna to occur, it is also necessary to identify likely habitats and the extent of those habitats.<br>A summary of surveys and assessment of habitats relevant to the Proposal is provided as Appendix 9.<br>**Troglofauna**<br>Over the span of the historical surveys, troglofauna were only recovered in the most recent survey. The recent survey yielded ten potentially troglobitic species. The majority of potentially troglobitic species recorded were collected as singletons, i.e. known only from a single individual at a single location. Most of the species are therefore known only from within the Proposal Area.<br>Only one of the recorded potentially troglobitic species, *Embioptera* sp. indet is associated with the Proposal. A single juvenile specimen was collected from a bore in Deposit A west. Classification to family level was not possible because only adult males can be taxonomically identified. Little is known about troglobitic *Embioptera*. Generally they have limited distribution due to the flightless nature of the females, and morphologically distinct groups appear to be geographically restricted. This species is thus considered to represent a potential SRE. | Higher levels of endemicity have been found to be characteristic of subterranean taxa, and endemic species tend to be concentrated in habitats that support relatively diverse communities, rather than being distributed randomly (Biota 2004b).<br>The high levels of endemism that this fauna can exhibit may be due in part to poor dispersal capabilities. The dispersal of fauna inhabiting subterranean environs may be extremely slow and may be limited by the geological formation in which they occur. Many species have not been able to disperse a significant distance from their place of origin. Physical variables such as temperature and humidity may also influence the distribution of some subterranean species on a local and microhabitat scale (Danielopol *et al*. 1994 in Biota 2004b).<br>Recent surveys and research have suggested that relatively localised impacts such as mining have the potential to significantly change the conservation status of locally endemic species (Eberhard and Humphreys 1999; Biota 2001 in Biota 2004b). However, no new or additional impacts to subterranean fauna are expected to result from implementation of this Proposal.<br>Recent surveys and research have suggested that relatively localised impacts such as mining have the potential to significantly change the conservation status of locally endemic subterranean fauna species through the following impacts:<br>• Excavation reducing subterranean habitat availability;<br>• Clearing reducing organic inputs to subterranean ecosystems;<br>• Dewatering, groundwater abstraction and other aquifer impacts reducing habitat availability for stygofauna and habitat quality for troglofauna;<br>• Changes to surface hydrology reducing rainfall recharge and the associated input of dissolved organic matter and nutrients to subterranean habitats;<br>• Vibration effects on subterranean habitats from blasting activities; and<br>• Contamination (e.g. pollutant spills) reducing the quality of subterranean fauna habitat.<br>However, subterranean fauna are not expected to be impacted by the Proposal given the following:<br>• No species listed under the EPBC Act, WC Act or by Parks and Wildlifeas critical, endangered or vulnerable have been recorded during the surveys.<br>• Stygofauna have not historically been recorded from, and are not expected to be recorded from, within the confined (i.e. low hydraulic connectivity) aquifers associated with the deposits. | The Proposal meets the EPA's objective for this factor and it is therefore not considered a key environmental factor.<br>The subterranean fauna sampling and habitat characterisation conducted within the Proposal area provides evidence to support that the Proposal will not have a significant impact on subterranean fauna biodiversity values at local or regional scales.<br>Dewatering will continue to be managed under the existing RIWI Act (5C Licence to Take) and associated Groundwater Operating Strategy and any amendments as required.<br>In addition, the following key management measures from the Environmental Management Program (Appendix 7) have been, and will continue to be, implemented to manage potential impacts on subterranean fauna:<br>• Water supply will be sourced from dewatering bores wherever practicable to reduce potential for drawdown in the Jeerinah Formation.<br>• Where stygofauna are known to be present in an aquifer, that aquifer will be monitored for subterranean habitat parameters (water levels and water quality).<br>• In the event that new bores are to be installed within an aquifer that has not yet been monitored for stygofauna, a stygofauna assemblage baseline survey should be undertaken. If sampling indicates that stygofauna species of significant conservation value are present, bores will be added to the monitoring schedule for subterranean habitat parameters. |

| Factor | EPA Objective | Description of Factor | Impacts | Existing Management and Mitigation Measures |
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| | | The occurrence of the apparently endemic species *Embioptera* sp. indet, likely reflects a sampling artefact rather than a true reflection of a potentially restricted range. It is considered probable that the range of this species extends in continuous habitat.<br><br>The Marra Mamba Iron Formation is not considered core habitat for the persistence of significant populations of troglofauna. Deposits A west and F are considered 'typical' of Marra Mamba Iron Formation. The massive-textured geology of these deposits does not provide suitable interconnected cavities or void spaces, suggesting that the distribution of subterranean fauna is likely to be limited in this formation.<br><br>Moreover, this geological formation is well-represented in the region. Even if the sedimentary rocks of the Marra Mamba Iron Formation hosted some troglofauna, the proposed area of Marra Mamba Iron Formation affected by mining is negligible is comparison to the overall area of the formation present in the wider region.<br><br>Local fracture systems and weathered zones associated with regional lineaments are one of the only parts of the Marra Mamba Iron Formation which represent potential troglofauna habitat. It is likely that these fractured and weathered zones extend vertically and horizontally outside of the deposits suggesting there is habitat continuity through areas where the species was not recorded. It may be reasonably expected that if troglofauna were present within are local fracture systems and weathered zones, then they would be well represented across the entire area.<br><br>Hydrated, vuggy-textured material has also previously been identified as potential troglofauna habitat elsewhere in the Pilbara. The widespread regolith of hydrated material, which is commonly intersected in the Mount Newman Member close to the surface, is the only other part of the formation which potentially can exhibit micro-vughy textures. Hydrated zones extend beyond the deposits (i.e. they occur both locally and regionally). It is therefore likely that troglofauna habitat extends into continuous habitat in the surrounding strata.<br><br>The deeper geological units that are saturated (below the water table) do not support troglofauna communities.<br><br>**Stygofauna**<br><br>Over the span of the historical surveys stygofauna were recovered from bores within both the Turee Creek B borefield and the West Angelas borefield. The majority of potentially stygobitic species were collected in low abundance.<br><br>Distribution patterns of stygofauna in aquifers are considered to be determined by hydraulic connectivity rather than associated with particular geologies. Stygofauna require adequate hydraulic connectivity to allow food and oxygen to be distributed from the surface to the groundwater. | • The Proposal has the potential to impact the potentially locally endemic troglofauna Embioptera sp. indet which was collected from a bore in Deposit A west however, the known range of 'restricted' species, particularly those represented by a single specimen, is likely to be an underestimate. It is considered probable that the range of this 'restricted' species will extend in continuous habitat.<br><br>• Adequate sampling (as per EPA (2013)) has occurred. Low capture rates mean Rio Tinto is using habitat as a surrogate for the distribution of subterranean fauna taxa, as per the approach outlines in EPA (2013).<br><br>• The Marra Mamba Iron Formation is not considered core habitat for the persistence of significant populations of troglofauna. Moreover, even if the Marra Mamba Iron Formation hosted some troglofauna, the proposed area of Marra Mamba Iron Formation affected by mining is negligible is comparison to the continuous extent of Marra Mamba formation within the syncline and overall area of the formation present in the wider region.<br><br>• Local fracture systems and weathered zones as well as hydrated material, which represent potential troglofauna habitats both connect and extend outside of the deposits suggesting there is habitat continuity through areas where species were not recorded. It may be reasonably expected that if troglofauna were present, then they would be well represented within the local area.<br><br>For these reasons, subterranean fauna is not considered a key environmental factor relevant to this Proposal. | |

| Factor | EPA Objective | Description of Factor | Impacts | Existing Management and Mitigation Measures |
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| | | Open (porous, fractured and karstic) aquifers have abundant interstitial space and at least moderate hydraulic conductivity. There is continuous exchange with surface water for food and oxygen supply, which is why stygofauna communities are often found in this aquifer type (Hahn and Fuchs 2009). Historically, the Turee Creek B borefield, which is located within an open aquifer, has yielded stygofauna (*ecologia* 2013).<br><br>Confined and / or compact aquifers have low hydraulic conductivity and are not considered overly prospective habitat for stygofauna according to classifications by the EPA (2013). These types of aquifers have minimal interstitial space and reduced food and oxygen supply, which is why these aquifer types are usually either devoid of stygofauna or have depleted taxonomic richness and abundance (Hahn and Fuchs 2009 in *ecologia* 2013). Historically, the Deposit A aquifer, which is a confined aquifer has returned no stygofauna (Biota 2003, 2008).<br><br>Given the depth and hydraulically confined nature of the Deposits A west and F aquifers, these aquifers are considered unlikely to support significant populations of stygofauna. This does not preclude the potential occurrence of stygofauna if the aquifers have secondary hydraulic conductivity in the form of local fractures. However, the historic sampling of the Deposit A, which failed to detect stygofauna, suggests there is a low likelihood of a diverse and abundant stygofauna community being present in these analogous aquifers. | | |

| Factor | EPA Objective | Description of Factor | Impacts | Existing Management and Mitigation Measures |
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| Terrestrial Environmental Quality | *To maintain the quality of land and soils so that the environment values, both ecological and social, are protected.* | The Proposal will generate approximately 130 $Mm^3$ of mineral waste rock. Waste rock will be transported by haul trucks to external waste dumps according to the material categorisation. Where practicable, waste may also be used in progressive backfilling of the pits to assist in achieving closure objectives for the site.<br><br>Other wastes generated by the proposal will include:<br>• inert and putrescible domestic and industrial wastes;<br>• liquid wastes including ablution effluent;<br>• hazardous waste including hydrocarbons, chemicals, used oils and greases<br><br>Inert and putrescible domestic and industrial wastes associated with the Proposal will continue to be disposed of to the existing on-site landfill facility.<br><br>Bulk quantities of fuel required for ongoing operations will continue to be stored in on-site bulk fuel storage facilities. Fuel storage and handling will be in accordance with Australian Standard (AS) 1940 "The storage and handling of flammable and combustible liquids" and/or the *Dangerous Goods Safety (Explosives) Regulations 2007* and their updates. | Wastes, if inappropriately managed, have the potential to contaminate soils.<br><br>Waste generation is not expected to be significantly greater than or different to existing operations. Wastes will continue to be handled, stored, treated and / or disposed of in a manner that minimises the risk to both ecological and social values. | The Proposal meets the EPA's objective for this factor and it is therefore not considered a key environmental factor.<br><br>Wastes associated with the Proposal will be managed using existing facilities, in accordance with relevant approvals and legislation. Operating licence L7774/2000, issued under Part V of the EP Act, contains specific requirements for the management of wastes within the prescribed premise boundary. The licensee will consult DER if additional approvals are required.<br><br>In addition, Rio Tinto has well established management strategies for the management of waste materials at its Pilbara operations. The Waste Management Plan (Appendix 7) has been, and will continue to be implemented to ensure waste materials are adequately managed in accordance with the waste management hierarchy of elimination, reduction, reuse, recycling, treatment and disposal. The following key management measures from the Waste Management Plan have been, and will continue to be, implemented to manage potential impacts of waste:<br>• An inventory of wastes generated, handled and disposed of on-site and off-site will be developed and maintained.<br>• Assessment of the environmental risks associated with wastes generated and disposed of on-site will be developed and maintained.<br>• On-site waste storage, treatment and disposal facilities will be inspected on a regular basis to ensure compliance.<br>**Mineral Waste**<br>• Mineral waste will be used in progressive backfilling of mine pit voids to above the natural ground water level as far as practicable.<br>**Domestic and Industrial Waste**<br>• Waste generation will be minimised through the adoption of the waste management hierarchy (reduce, reuse, recycle) where practicable.<br>• Management of domestic and industrial waste will include:<br>o waste segregation,<br>o burning of waste will be prohibited, and<br>o sufficient number and appropriate placement of bins.<br>• The following will be disposed of at landfill facilities, which will be managed in accordance with licences and appropriate landfill guidelines:<br>o putrescibles (food scraps);<br>o biodegradables (e.g. paper, cardboard);<br>o inert materials (e.g. concrete, steel, wood); and<br>o other general rubbish (e.g. plastics). |

| Factor | EPA Objective | Description of Factor | Impacts | Existing Management and Mitigation Measures |
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| | | | | • The landfill will be fenced and backfilled on a regular basis to prevent wind-blown litter and feral animal foraging.<br>**Ablution effluent**<br>• Ablution effluent will be managed via appropriately licenced wastewater treatment facilities.<br>• Wastewater treatment facilities will be routinely maintained.<br>• Effluent from the wastewater treatment plant (WWTP) will be discharged within designated irrigation area.<br>**Hazardous Waste**<br>• An inventory of hazardous materials on-site will be maintained.<br>• Hazardous waste materials will be segregated from the general waste stream.<br>• Hazardous waste materials will be collected as required by appropriately licenced controlled waste contractors for offsite disposal.<br>• Assessments of contractors and facilities will be undertaken to ensure that wastes sent off site for disposal or treatment are appropriately dealt with.<br>• Appropriate spill response equipment will be located nearby to work areas where hazardous materials are frequently used, such that it is available for immediate use.<br>**Hydrocarbons**<br>• Hydrocarbons will be handled, stored and disposed of in accordance with all legal requirements.<br>• Hydrocarbon storage facilities and all associated connections will be within appropriately bunded areas.<br>• Hydrocarbon storage facilities and bunds will be inspected on a regular basis to identify any leaks or maintenance requirements.<br>• Any hydrocarbon contaminated soil will be remediated and/or disposed of as appropriate.<br>• Hydrocarbon waste materials not suitable for onsite disposal will be collected as required by appropriately licenced controlled waste contractors for offsite disposal or recycling.<br>**Spill Response**<br>• All spills will be managed in accordance with the requirements of spill response procedures.<br>• Significant spills will be managed in accordance with emergency response procedures.<br>• Appropriate spill response equipment will be located nearby to work areas such that it is available for immediate use. |

| Factor | EPA Objective | Description of Factor | Impacts | Existing Management and Mitigation Measures |
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| Inland Waters Environmental Quality | *To maintain the quality of surface water, sediment and/or biota so that the environmental values, both ecological and social, are protected.* | Rio Tinto has undertaken an extensive program of geochemical testing, over several years, to understand the potential for acidification and / or metal enrichment to occur as a result of the various waste types common to mining operations in the Pilbara.<br><br>The most significant geochemical risk in Pilbara iron ore bodies is associated with sulphides, such as pyrite ($FeS_2$), which can form sulphuric acid when exposed to oxygen and water. Mt McRae Shale, the geological unit most commonly associated with pyrite and acid mine drainage in the Pilbara, is not present at West Angelas. However, pyrite can also occur in Banded Iron Formations.<br><br>Two hundred samples from the West Angelas deposits (ore and waste samples) have been submitted for Acid Base Accounting (**ABA**) and geochemical characterisation. For lithologies such as banded iron formation and detrital rock types, a value of 0.3% total sulphur concentration has been adopted as the boundary value to denote potentially acid forming (**PAF**) material from inert/non-acid forming (**NAF**) material. Samples associated with elevated-sulphate (where sulphur values may range from 0.1% to greater than 1%) have been classified as PAF.<br><br>**Deposits A west, B and D**<br><br>Overall, 92% of the samples submitted for ABA were classified as NAF. The remaining 8% of samples were classified as PAF or PAF in a low capacity (PAF-LC).<br><br>The PAF samples are predominately from the Newman Member of the Marra Mamba Iron Formation. These samples are banded iron formation waste samples and the majority had visible pyrite logged. The PAF-LC samples are expected to have few sulphides present with the majority of the acid produced from the precipitation of metallic ions as hydroxides between pH 4.5 and 7. It is expected that material and water encountered on site will provide sufficient neutralisation capacity to offset the low levels of acid produced.<br><br>Further analysis of sulphur values was undertaken on those rock types identified with acid-forming potential (and any related metaliferous drainage). The risk posed by the high sulphur values is determined by comparing the occurrence of sulphur levels greater than 0.1% and 0.3% against the total number of recorded drill samples for all in-pit (waste and ore) samples. These results suggest the risk of acid drainage being generated during the operation and / or from mineral waste materials from all deposits is low.<br><br>**Deposit F**<br><br>Overall, 41 samples (98%) were classified as NAF and one sample (2%) was classified as PAF. The PAF sample was taken from a depth that is below the current available pit designs, and is unlikely to be exposed during mining. | AMD is produced by the exposure of sulphide minerals such as pyrite to atmospheric oxygen and water. PAF material has the potential to generate AMD if not appropriately characterised and managed.<br><br>The AMD assessment concluded that the risk of AMD being generated from all deposits is low. | The Proposal meets the EPA's objective for this factor and it is therefore not considered a key environmental factor.<br><br>Rio Tinto has well established management strategies for the management of PAF materials at its Pilbara operations. The Rio Tinto Iron Ore (WA) Mineral Waste Management Plan, and the Spontaneous Combustion and ARD (**SCARD**) Management Plan have been, and will continue to be implemented to ensure waste material is adequately geochemically characterised, and PAF material that poses an AMD risk is appropriately managed. |

| Factor | EPA Objective | Description of Factor | Impacts | Existing Management and Mitigation Measures |
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| | | A multi-element analysis was also undertaken for all drillhole samples taken from Deposits A, A west, B, E and F. In general, whilst concentrations of some trace elements of potential environmental concern (e.g. Fe, As, Sb, Se and S) were enriched or elevated in some of the sampled ore and waste materials, these elements will not necessarily mobilise into groundwater. Although As, Sb and Se were determined to be enriched in samples, the leach tests indicated that these elements did not leach at levels exceeding the detection limit. Arsenic in particular is commonly enriched in ore and waste for many Hamersley Group deposits. Iron oxy-hydroxides such as hematite and magnetite have high sorption capacities for arsenic. Groundwater contamination with arsenic is considered to be unlikely, based on historical groundwater assessments at West Angelas and experience from similar deposits in the Pilbara. Lead is similarly unlikely to mobilise into the groundwater and cause any environmental concern. | | |

| Factor | EPA Objective | Description of Factor | Impacts | Existing Management and Mitigation Measures |
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| Hydrological Processes and Inland Waters Environmental Quality (Groundwater) | *To maintain hydrological regimes of groundwater and surface water so that existing and potential uses, including ecosystem maintenance, are protected.*<br><br>*To maintain the quality of groundwater and surface water, sediment and/or biota so that the environmental values, both ecological and social, are protected.* | Groundwater throughout the West Angelas region is naturally deep. Resources for both Deposits A west and F are mostly above water table. Approximately 6% of the Deposit A west resource and 1% of the Deposit F resource is below the water table.<br><br>The aquifer at Deposit A west is associated with a mineralised section of the Mount Neman Member of the Marra Mamba Iron Formation and the overlying Wittenoom Formation (Figure 9-1).<br><br>The water table elevation at Deposit A west is nominally 625 m RL, or approximately 90 m below ground level (m bgl). Dewatering up to 18 ML/day is expected to enable mining to a depth of approximately 40m below the water table. Based on observed differences in groundwater elevation and the "bathtub" type nature of the Deposit A aquifer, it is likely that Deposit A west is hydraulically separated from Deposit A.<br><br>The aquifer at Deposit F is also associated with a mineralised section of the Mount Neman Member of the Marra Mamba Iron Formation and the overlying Wittenoom Formation (Figure 9-2).<br><br>The water table elevation at Deposit F varies from approximately 686 m RL, or approximately 95 m bgl in pit F1 to 670 m RL, or approximately 118 m bgl in pits F2 and F3. Dewatering up to 3 ML/day is expected to enable mining to a depth of approximately 25 m below the water table. Based on observed differences in groundwater elevation, it is thought that pit F1 is hydraulically separate from pits F2 and F3, as well as the nearby Deposit E.<br><br>Groundwater is not expected to support phreatophytic species given the depth to the water table.<br><br>West Angelas is considered to be a water neutral (to small deficit) site in terms of water balance; operational water demand is roughly equivalent to dewatering requirements. While the site as a whole is water neutral, the water management of each deposit is different with some in deficit and others in surplus. Water sources are integrated to ensure continuity of supply across West Angelas. This integrated water management strategy will continue to be implemented to address water supply and demand requirements for the Revised Proposal. Dewatering at Deposit A west is likely to meet demand with a small surplus available for use elsewhere while a water deficit is predicted for Deposit F; additional water sources are likely to be required to meet demand.<br><br>Any surplus water, exceeding operational water demand is discharged to the environment.<br><br>Groundwater sampling and analysis of water quality indicates that the groundwater is of good quality. | Abstraction of groundwater for the Proposal is expected to have minimal impact on groundwater levels in the area due to the minor volumes extracted. Additionally, studies undertaken to date indicate any impacts on groundwater levels will be localised, there will be no significant impacts on regional groundwater levels.<br><br>Analysis of water quality indicates that the groundwater is of good quality therefore, no impact is expected as a result of discharge to the environment. | The Proposal meets the EPA's objective for this factor and it is therefore not considered a key environmental factor.<br><br>Abstraction of groundwater at West Angelas has been approved under Groundwater Licence GWL98740, under the RIWI Act. Groundwater abstraction will continue to be managed under the existing RIWI Act Licence and associated Groundwater Operating Strategy, and any amendments as required.<br><br>Discharge to the environment has been approved under operating licence L7774/2000, issued under Part V of the EP Act. The licensee will consult DER if additional dewatering discharge approvals are required.<br><br>In addition, the following key management measures from the Environmental Management Program (Appendix 7) have been, and will continue to be, implemented to manage potential impacts on groundwater:<br><br>• A 'site water balance' will be developed and maintained to facilitate site's understanding of current and future water demands.<br><br>• Water will be used on-site wherever practicable. Only water exceeding on-site requirements will be discharged to the environment.<br><br>• The volume of groundwater abstracted has been, and will continue to be, recorded, reconciled regularly against the licence limit and will not exceed the licence limit.<br><br>• A water level elevation monitoring program has been, and will continue to be, implemented for groundwater.<br><br>• A water quality monitoring program has been, and will continue to be, implemented for groundwater.<br><br>• Pits will be backfilled to above the natural ground water level as far as practicable to minimise the deterioration of groundwater quality.<br><br>• Monitoring to assess the impacts of drawdown on phreatophytic vegetation (*Eucalyptus* sp.) has been, and will continue to be, undertaken. |

| Factor | EPA Objective | Description of Factor | Impacts | Existing Management and Mitigation Measures |
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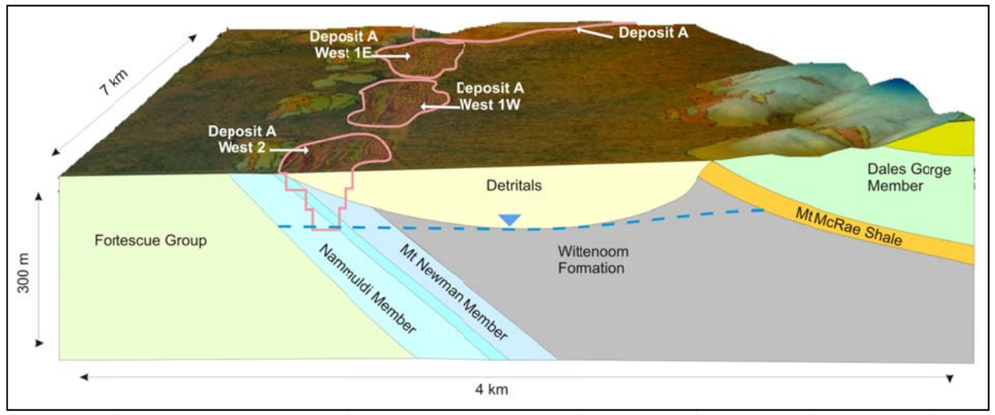


**Figure 9-1: Conceptual Cross-Section of Deposit A west**

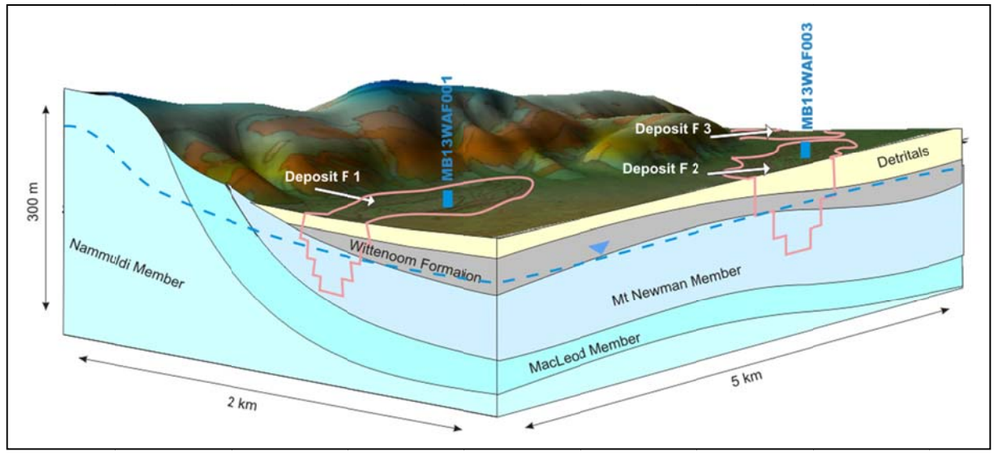


**Figure 9-2: Conceptual Cross-Section of Deposit F**

| Factor | EPA Objective | Description of Factor | Impacts | Existing Management and Mitigation Measures |
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| Air Quality | *To maintain air quality for the protection of the environment and human health and amenity.* | The Proposal will generate dust, noise, vibration and Greenhouse Gas (**GHG**) emissions.<br>**Dust**<br>Particulate emissions resulting from this Proposal are associated with:<br>• vehicle activity – heavy mining equipment and light vehicles on unsealed surfaces;<br>• mining and processing – blasting, loading, hauling, crushing, conveying, screening and stockpiling material; and<br>• wind erosion – in dry, windy conditions, particles can be lifted from disturbed areas.<br>No modelling of projected cumulative particulate emissions was undertaken as dust emissions generated by the Proposal are not expected to be greater than or different to those from existing operations.<br>**Noise and Vibration**<br>A 100 m exclusion zone will be maintained for the potential ghost Bat maternity cave (AA1); however, blasting at Deposit F has the potential to result in vibration. There are no legislated criteria regarding vibration levels at sensitive biological receptors.<br>**GHG**<br>No GHG emissions assessment was undertaken as it is considered that the emissions generated by the Proposal will essentially be similar to those of existing operations.<br>West Angelas is seen as a relatively small emitter of GHG. The key energy demand for the Proposal is diesel consumption. Diesel consumption estimates for the Proposal (i.e. considering only the consumption associated with Deposits A west and F, and not the total impact for the Revised Proposal) is approximately 135 ML for Deposit A west and approximately 195 ML for Deposit F. | **Dust** emissions will continue to be mitigated as far as reasonably practicable such that potential health and safety issues at the only nearby sensitive receptor, the village, are not expected to be significantly greater than or different to those of existing operations.<br>**Vibration** from blasting at Deposit F could damage the integrity of the potential ghost Bat maternity cave (AA1). Collapse could potentially be a significant loss to the regional Ghost Bat population.<br>**GHG** emissions are not expected to be significantly greater than or different to those of existing operations. Greenhouse gas emissions will be mitigated as far as reasonable practicable and will be managed in to meet environmental greenhouse gas emission standards. | The Proposal meets the EPA's objective for this factor and it is therefore not considered a key environmental factor.<br>Emissions are not expected to be significantly greater than or different to those of the existing operations.<br>Emissions and discharges are primarily regulated under Part V of the EP Act, unless the environmental impact is significant and warrants EIA by the EPA under Part IV of the Act (EPA 2012). Emissions from the existing operations have been, and will continue to be, managed under the existing operating licence. The licensee will consult the DER if additional approvals are required.<br>Additionally, GHG emissions have been, and will continue to be managed under the *Clean Energy Act 2011* (Cwth) and the *National Greenhouse and Energy Reporting Act 2007* (Cwth).<br>Impacts on community receptors from nuisance dust, noise and vibration are expected to be limited, and therefore no specific management strategy is required. However, the following key management measures from the Environmental Management Program (Appendix 7) have been, and will continue to be, implemented to manage potential impacts of dust, noise and vibration:<br>**Dust**<br>• Clearing has been, and will continue to be planned such that vegetated areas are retained until required ahead of mine development.<br>• Disturbed areas have been, and will continue to be progressively rehabilitated, where possible.<br>• Watering from water tankers and / or other appropriate dust suppression methods have been, and will continue to be undertaken at areas prone to dust generation, including:<br>o access road;<br>o haul roads;<br>o active pit areas;<br>o mineral waste and topsoil stockpiles, and<br>o cleared areas, as required.<br>• Crushing and screening facilities have been, and will continue to be operated with suitable dust suppression and extraction systems, screens and / or sprays.<br>• The train loadout facility has, and will continue to use water sprays to reduce dust generation.<br>• Regular housekeeping has been, and will continue to be undertaken to prevent an accumulation of material in or around plant facilities that may result in dust.<br>• Dust suppression equipment will be maintained in an efficient operating condition. |

| Factor | EPA Objective | Description of Factor | Impacts | Existing Management and Mitigation Measures |
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| | | | | • Vehicle access has been, and will continue to be restricted to designated tracks and roads as far as practicable.<br>• Vehicle speed limits have been, and will continue to be prescribed to reduce dust lift-off from unsealed roads.<br>• High use roads have been, and will continue to be sealed where practicable<br>**Noise and Vibration**<br>• Blast vibration control, including vibration risk assessment, controlled blasting and vibration monitoring has been, and will continue to be implemented to ensure that the caves are protected. |

| Factor | EPA Objective | Description of Factor | Impacts | Existing Management and Mitigation Measures |
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| Amenity<br>(Visual) | *To ensure that impacts to amenity are reduced as low as reasonably practicable.* | The location of West Angelas is very remote, with no neighbouring mining or pastoral activities. The nearest town, Newman, is located approximately 130 km south-east of West Angelas.<br>The visual landscape in the region is predominantly natural in appearance, with localised areas of highly modified landscapes due to mining. | Visual impact of the Proposal is not expected to be different or additional to that of the existing West Angelas Project, in consideration of the following:<br>• The Proposal is an extension to the existing operation.<br>• The Proposal is remote from communities or other sensitive areas such as scenic outlooks or National Parks.<br>• There are no public roads in the vicinity to facilitate access. | The Proposal meets the EPA's objective for this factor and it is therefore not considered a key environmental factor.<br>Impacts on the visual amenity of community receptors are expected to be limited, and therefore no specific management strategy is required.<br>The following key management measures from the Environmental Management Program (Appendix 7) have been, and will continue to be, implemented to manage potential impacts on visual amenity:<br>• The design (height and slope) of mineral waste dumps will consider:<br>o minimisation of dump height;<br>o shaping of dumps to blend in with the surrounding natural topography;<br>o construction to meet the requirements of the final rehabilitation design; and<br>o drainage and erosion management features.<br>• Progressive backfilling will be implemented as far as practicable.<br>• Progressive rehabilitation with local native vegetation has been, and will continue to be, undertaken where possible.<br>The following closure objectives will also ensure that impacts to amenity are reduced as low as reasonably practicable at closure:<br>• Minimise the long term visual impact by reshaping the land so it is compatible with the adjacent landscapes; and<br>• Re-establish self-sustaining ecosystems. |

| Factor | EPA Objective | Description of Factor | Impacts | Existing Management and Mitigation Measures |
|---|---|---|---|---|
| Heritage | *To ensure that historical and cultural associations are not adversely affected.* | This Proposal is located within the traditional lands of the Yinhawangka and Ngarlawangga people. The Yinhawangka People are the native title claimants and traditional custodians of the majority of the land. The Ngarlawangga People are the native title claimants for a portion of the Deposit F area.<br><br>West Angelas has an existing Section 18 consent under the *Aboriginal Heritage Act 1972* (**AHA**) that was granted by the Minister for Aboriginal Affairs in January 2000. Sites that will be impacted by pits will require additional Section 18 AHA consent.<br><br>Archaeological and ethnographic surveys have been undertaken over the majority of the Proposal area. To date no ethnographic sites have been identified. A number of heritage sites have been identified at both Deposits A west and F.<br><br>At Deposit A west the majority of the heritage sites include artefact scatters. Based on the current design for A west, three artefact scatters will be impacted. Section 18 consent will need to be sought for impact to these sites.<br><br>At Deposit F the sites identified include rock shelters, scarred trees and artefact scatters. A significant rock shelter containing rock art is located approximately 500 m to the north of pit F2.<br><br>Based on the current design for Deposit F, one artefact scatter will be directly impacted in pit F2. Three rock shelters within immediate proximity of pit F1 may be affected by indirect impacts as a result of blasting. Additionally, a rock shelter and scarred tree located within vicinity of pit F2 may also be affected by indirect impacts. Section 18 consent for these sites will need to be sought and the rock shelters may require archaeological excavation. | Surveys undertaken to date indicate the Proposal is unlikely to have significant impact on Aboriginal heritage, in addition to or different from the existing West Angelas Project:<br><br>• No ethnographic sites have been identified to date.<br><br>• Archaeological sites identified include rockshelters, scarred trees and artefact scatters. Some of the archaeological sites identified may be impacted by the Proposal; however, these sites are of low to moderate significance.<br><br>• If sites cannot otherwise be avoided, the impacts will be managed in accordance with the AHA Section 18, and in consultation with Traditional Owners.<br><br>• The significant rockshelter containing rock art, located approximately 500 m to the north of pit F2 is not at risk of impact from current mine plans, however monitoring of the site will be required. | The Proposal meets the EPA's objective for this factor and it is therefore not considered a key environmental factor.<br><br>It is not expected that Aboriginal Heritage values will be impacted by this Proposal.<br><br>Ongoing engagement with Traditional Owners is managed and maintained through engagement frameworks established through our agreements. This ensures all activities occur with ongoing engagement with both groups.<br><br>Management strategies from the existing West Angelas Cultural Heritage Management Plan have been, and will continue to be, implemented for the protection and conservation of cultural heritage at the site. |

# 10 CUMULATIVE IMPACTS

Cumulative impacts can arise where operation level impacts act synergistically, cause indirect impacts or combine to exacerbate impacts spatially and/or through time. In the case of Pilbara mining projects, a principal concern is the potential for multiple mining projects to incrementally diminish and degrade environmental values that would otherwise not be significantly affected by each project in isolation.

Robe's knowledge of current and potential mining projects in the region, in addition to the Revised Proposal, is limited to the following seven iron ore mines (refer to Figure 1-1):

- Mining Area C is located approximately 35 km north-north east of West Angelas;
- Hope Downs is located approximately 45 km north east of West Angelas;
- Yandi (Marillana Creek) is located approximately 60 km north-north east of West Angelas;
- Yandicoogina is located approximately 65 km north east of West Angelas;
- Hope Downs 4 is located approximately 85 km east of West Angelas;
- Marandoo is located approximately 90 km north west of West Angelas; and
- Mount Whaleback is located approximately 95 km north east south-east of West Angelas.

Given its distance from the nearest existing operations, absence of unique or unusual ecological features, and the relatively small scale of clearing proposed, Robe does not consider that the Revised Proposal will contribute to significant cumulative impacts. An assessment of the potential for cumulative impacts in relation to the Revised Proposal is summarised in Table 10-1.

**Table 10-1: Assessment of potential for cumulative impacts**

| Possible cumulative impact | Description and assessment of significance |
|---|---|
| Disturbance to landforms | The Revised Proposal does not intersect landforms with elevated conservation significance or other special interest. Whilst existing and potential future operations may affect the same land systems, all of the land systems mapped are widely distributed across the Pilbara. Therefore no significant cumulative impacts are predicted. |
| Disturbance to vegetation and flora | The Revised Proposal is an extension to existing West Angelas operations. The location is very remote with no neighbouring mining or pastoral activities.<br>The Revised Proposal does not intersect vegetation of high conservation significance. All vegetation units and Priority Flora species that will be disturbed by this Revised Proposal are well represented in the Pilbara bioregion. Therefore no significant cumulative impacts are predicted. |
| Disturbance to habitat for fauna species | The Revised Proposal does not intersect habitats of regional significance for rare and endangered fauna species. All of the habitat types that will be disturbed by this Revised Proposal are well represented in the Pilbara bioregion. Therefore no significant cumulative impacts are predicted. |

| Possible cumulative impact | Description and assessment of significance |
|---|---|
| Disturbance to hydrological processes | The Revised Proposal involves the discharge of surplus water to a nearby unnamed tributary of Turee Creek East. No other known current or potential mining projects in the region thereby avoiding the potential for cumulative impacts to occur within Turee Creek East as a result of discharge from multiple operations.<br><br>The Revised Proposal also involves the diversion of surface water to the adjacent Weeli Wolli catchment. The additional catchment contribution will have a negligible effect on the natural hydrological regime of the receiving catchment, with no increase in flow expected 30 km downstream, in events up to a 20% AEP. Given that the nearest operation which contributes additional water to Weeli Wolli is located approximately 45 km downstream, the diversion does not contribute to cumulative impacts in the local catchment. |

# 11 RESIDUAL IMPACTS: IMPACT ASSESSMENT AND MANAGEMENT

## 11.1 DETERMINATION OF CRITICAL AND HIGH VALUE ASSETS

EPA Position Statement No. 9: Environmental Offsets (EPA 2006a) and EPA Guidance Statement No. 19: Environmental Offsets (EPA 2008a) provide guidance to proponents on the approach needed to determine offset requirements for proposals.

The definitions of critical and high value assets EPA Position Statement No. 9 are as follows:

> *Critical Assets: represent the State's most important environmental assets that must be fully protected and conserved. Significant adverse impacts to these assets should be avoided at all costs. Therefore, the EPA in providing its advice will adopt a presumption against approval of project proposals where significant adverse impacts affect 'critical assets'. However, where projects have been approved by the State Government, approval should be conditional on the:*
>
> - *consideration or demonstration (to the maximum extent possible) of onsite impact mitigation; and*
> - *development and implementation of an acceptable offsets package for significant, residual adverse impacts.*
>
> *High Value Assets: represents those environmental assets that are in good to excellent condition, are considered valuable by the community and / or government, but are not identified as 'critical assets'. Project proposals and offset activities for these assets may be referred to and assessed by the EPA on a case-by-case basis, but are otherwise considered by relevant environmental government agencies.*

Environmental aspects of the Proposal were assessed for their potential value as critical or high value assets. Environmental aspects meeting the requirements for either category have been included in the determination of appropriate offsets.

The Proposal does not lie within a reserve or protected area. Vegetation mapping has been completed and does not indicate the presence of any vegetation types that qualify for specific legislative protection (i.e. TECs). The Priority 1 West Angelas Cracking-Clay PEC occurs extensively within the area. None of the other vegetation types identified were considered to be sufficiently rare or restricted to warrant designating them as being of high conservation significance. The grove/intergrove and valley floor mulga were considered to have moderate conservation significance. The remainder of the vegetation types were considered to be of low conservation significance, representing units that are likely to be widely distributed and relatively well represented in the region. Vegetation communities were generally found to be in Very Good to Excellent condition despite evidence of weed invasion.

Whilst some occurrences of Priority listed species (flora and fauna) have been recorded, none of these were found to be restricted to the Proposal area and therefore have not been individually classified as 'high value assets'.

## 11.2 OFFSET REQUIREMENTS FOR THE PROPOSAL

The EPA (2012) considers that the increased amount of clearing of native vegetation in the Pilbara Bioregion, combined with the predicted future activities requiring clearing and other impacts from pastoralism and fires, is likely to result in a significant impact on environmental values. Subsequently the EPA has determined that a proactive approach to limiting these impacts is required and that a possible solution is the establishment of a strategic regional conservation initiative for pooling of offset funds for the Pilbara.

As a result, offsets for clearing of native vegetation considered in good to excellent condition have consistently been applied for in the Pilbara Bioregion. Where there is an additional level of environmental value, a higher offset has been applied to account for this greater value. This approach has generally applied for all proposals within the Fortescue subregion, as well as some that are in the Hamersley subregion.

An assessment of potential impacts of the Proposal was undertaken in accordance with EPA Position Statement No. 9, *Environmental Offsets* (EPA 2006) and EPA Guidance Statement No. 19, *Environmental Offsets – Biodiversity* (EPA 2008). The Proposal is considered unlikely to have significant adverse impacts on any potential 'critical' or 'high value' assets, however, it is expected that an offset will be required for clearing of native vegetation in good to excellent condition.

The Hamersley subregion is fairly well represented (12.6%) within the conservation reserve system. Lower offset rates for clearing of native vegetation in good to excellent condition have therefore been applied in recognition of this fair representation (i.e. this below the target of 15%). It is expected that this lower offset rate will be applied to this Proposal.

Additionally, given that MS 970 does not specify the need for an offset, it is expected that the offset will be only applied to the additional clearing that forms part of this Proposal.

The Environmental Offsets Reporting Form is included in Table 11-1.

**Table 11-1: Environmental Offsets Reporting Form**

| **Section A: Administrative information** |
|---|
| **1. Proposal name:** West Angelas Iron Ore Mine – Revised Proposal |
| **2. Summary of Proposal:** The Proponent, Robe River Mining Co. Pty. Ltd. (a wholly owned subsidiary of Rio Tinto), on behalf of the Robe River Joint Venture Participants, proposes to mine iron ore from above and below the water table in Deposits A west and F, as satellite deposits to the existing West Angelas operations. Once mined, ore will be transported by haul trucks to existing processing facilities.<br><br>The Proposal will require additional clearing of approximately 3,220 ha.<br><br>The preferred surface water management option for Deposit A west is a diversion channel to redirect flows from the local catchment westwards, maintaining natural flows. A passive surface water management strategy is proposed for Deposit F pits F1 and F3, local catchments will be allowed to naturally terminate in the pits. The preferred surface water management option for Deposit F pit F2 is a diversion channel to redirect flows eastwards into the adjacent Weeli Wolli catchment. |
| **Section B: Type of environmental asset(s) – State whether Critical or High Value, describe the environmental values and attributes** |
| The Proposal is an extension to an existing, very remote mining operation located within an area where the dominant land uses are pastoral and mining.<br><br>No 'Critical' environmental assets are located within the development envelope. Environmental assets that are present within the development envelope that could be considered 'High Value' environmental assets defined in EPA Position Statement No. 9: Environmental Offsets (EPA 2006a) include:<br><br>• **West Angelas Cracking Clay Priority Ecological Community (PEC)**.<br><br>The Priority 1; West Angelas Cracking-Clay PEC occurs extensively within the area. This community is defined as 'open tussock grasslands of *Astrebla pectinata*, *A. elymoides*, *Aristida latifolia* in combination with *Astrebla squarrosa* and low scattered shrubs of *Sida fibulifera*, on basalt derived cracking-clay loam depressions and flowlines'. Threats to this community include; clearing for further mining expansion, weed invasion and changes in fire regimes.<br><br>• **Valley floor mulga communities.**<br><br>"Valley floor mulga" is a very broad description of mulga communities. The term "mulga" describes a group of Acacia species that were previously referred to as varieties of *Acacia aneura.* These communities are deemed to be "ecosystems at risk" (Kendrick 2001) and are therefore considered to be of local conservation significance. Threats to this community include grazing and trampling, weed invasion, and changes to hydrological regimes.<br><br>• **Potential Ghost Bat maternity cave AA1.**<br><br>The presence of a potential maternity cave for the Priority 4 listed species, the Ghost Bat (*Macroderma gigas*) represents the most significant record when considering the environmental significance of the Proposal. |

**Section C: Significant impacts (describe the significant adverse environmental impacts related to the proposal or scheme before mitigation measures are applied)**

Potential significant impacts on environmental assets from the Proposal are:

- The Proposal will result in clearing of up to 3,220 ha of vegetation, including vegetation communities which are considered to be of local conservation significance. Some occurrences of Priority Flora species will also potentially be cleared.
- The Proposal will result in the clearing of up to 3,220 ha of potential fauna habitat, therefore habitat loss is likely to continue to be the biggest threat to fauna, including several conservation significant fauna species (namely: Fork-tailed Swift, the Western Pebble-mound Mouse, the Short-tailed Mouse, the Ghost Bat, the Bush Stone-curlew and the Australian Bustard). Habitat fragmentation also has the potential to disrupt the movement of fauna.
- The Proposal includes diversion surface water flows. The resultant changes in the hydrological regime have the potential to impact on the receiving catchments and vegetation, including the Cracking Clay PEC and valley floor Mulga communities considered to be of local conservation significance.

**Section D: Mitigation measures (describe all measures to Avoid, Minimise, Rectify and Reduce)**

Mitigation measures to avoid, minimise, rectify and reduce impacts of the Proposal on environmental assets include:

***Avoid**:*

- Deposit A west has been designed to avoid the P1 West Angelas Cracking Clay PEC and changes to hydrological regime are considered negligible. Therefore the Cracking Clay PEC is not proposed to be detrimentally impacted by the Proposal.
- Deposit F has been designed to avoid the potential Ghost Bat maternity cave (AA1). Robe has also committed to maintain a 100 m exclusion zone to protect the integrity of the cave.
- Diversions have been designed to maintain natural surface water flows as far as practicable. Where it is not possible to continue flow within its natural catchment, surface water flows will be diverted to facilitate continued flow in the adjacent catchment.
- The backfill strategy has been adopted to prevent the formation of permanent pit lakes which could affect local or regional groundwater quality.

***Minimise:***

- Use of existing facilities will minimise clearing of undisturbed native vegetation.
- Additional clearing will be minimised as far as practicable and will avoid areas of elevated conservation significance as far as practicable.
- Diversions will be designed to protect receiving environments.

***Rectify and Reduce:***

- Where clearing is unavoidable, areas will be progressively rehabilitated with local native vegetation where possible.
- The Environmental Management Plan will be implemented to manage potential impacts of the Proposal on Key Environmental Factors.

| |
|---|
| • The Closure Plan will be implemented to ensure that the Proposal can be closed in an ecologically sustainable manner, consistent with agreed outcomes and land uses. |
| **Section E: Significant residual impacts (describe all the significant adverse residual impacts that remain after all mitigation attempts have been exhausted)** |
| The Proposal is considered unlikely to have any significant residual impacts to any 'Critical' or 'High Value' environmental assets. |
| **Section F: Proposed offsets for each significant residual impact (identify direct and contributing offsets). Include a description of the land tenure and zoning / reservation status of the proposed offset site. Identify any encumbrances or other restrictions on the land that may impact the implementation of the proposed offset and provide evidence demonstrating how these issues have been resolved.** |
| The Proposal is considered unlikely to have any significant residual impacts on any potential 'Critical' or 'High Value' assets, however, it is expected that an offset will be required for clearing of native vegetation in good to excellent condition. |
| **Section G: Spatial data relating to offset site/s (see *EPA Guidance Statement No. 19: environmental offsets- biodiversity*, Appendix 4)** |
| Coordinates defining the development envelope are held by the OEPA. Given that MS 970 does not specify the need for an offset, it is expected that the offset will be only applied to the additional clearing that forms part of this Proposal. |
| **Section H: Relevant data sources and evidence of consultation (consultation with agencies, relevant stakeholders, community and references to sources of data / information). Include details of specific environmental, technical or other relevant advice and information obtained to assist in the formulation of the offset.** |
| Vegetation and flora assessment undertaken (refer to Section 5); Terrestrial fauna assessment undertaken (refer to Section 6) |

# 12 OTHER LEGISLATION AND APPROVALS

Other legislation applicable to regulation of the potential environmental impacts of the Proposal, and approvals required, are outlined in Table 12-1. Robe will comply with all relevant legislation (including obtaining specific approvals where required) prior to, and during implementation of the Proposal.

**Table 12-1: Other Legislation and Approvals**

| Environmental factor | Secondary Approval | Responsible Agency | Statute |
|---|---|---|---|
| Flora and Vegetation | Native Vegetation Clearing Permit. | DMP | Part V of the *Environmental Protection Act 1986* |
| | Licence to take rare flora. | Parks and Wildlife | *Wildlife Conservation Act 1950* |
| Fauna | Licence to take protected fauna. | Parks and Wildlife | *Wildlife Conservation Act 1950* |
| Interference with watercourses | 26D Permit to obstruct or interfere with bed/banks. | DoW | *Rights in Water and Irrigation Act 1914* |
| Groundwater abstraction | 5C Licence to construct or alter wells.<br>Licence to take groundwater / amendment to existing groundwater licences. | DoW | |
| Emissions | Works Approval.<br>Amendment to existing Operating Licence. | DER | Part V of the *Environmental Protection Act 1986* |
| | National Greenhouse and Energy Reporting | DoE | *National Greenhouse and Energy Reporting Act 2007* |
| Rehabilitation and closure | Mining proposal and mine Closure Plan – required for infrastructure on Mining Act tenure. | DMP | *Mining Act 1978* |
| Heritage | Section 18 Consent to use land | DAA | *Aboriginal Heritage Act 1972* |

# 13 PRINCIPLES OF ENVIRONMENTAL PROTECTION AND EIA

This section describes how the objectives of the EP Act and the principles of Environmental Impact Assessment (**EIA**) have been addressed and how the Proposal meets the criteria for an Assessment of Proponent Information (**API**) (Category A) assessment as described in the *Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures 2012* (**2012 Administrative Procedures**) (EPA 2012a).

## 13.1 PRINCIPLES OF ENVIRONMENTAL PROTECTION

The concept of sustainable development came to prominence at the World Commission on Environment and Development (1987), in the report entitled Our Common Future, which defined sustainable development as; d*evelopment that meets the needs of the present without compromising the ability of future generations to meet their own needs.*

In recognition of the importance of sustainable development, the Commonwealth Government developed a National Strategy for Ecologically Sustainable Development (Commonwealth of Australia 1992) that defines Ecologically Sustainable Development (**ESD**) as "*…using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased.*

The principles of ESD are incorporated into the EP Act and the EPA's Position Statement No. 7 - Principles of Environmental Protection (EPA 2004c). These principles are listed below:

- The Precautionary Principle;
- The Principle of Intergenerational Equity;
- The Principle of the Conservation of Biological Diversity and Ecological Integrity;
- Principles in relation to Improved Valuation, Pricing and Incentive Mechanisms; and
- The Principle of Waste Minimisation.

These principles have been considered for the Proposal and are summarised in Table 13-1

.

**Table 13-1: Principles of Environmental Protection**

| Principle | Consideration Given in Proposal |
|---|---|
| **1. Precautionary principle**<br>Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.<br>In the application of the precautionary principle, decisions should be guided by:<br>• Careful evaluation to avoid, where practicable, serious or irreversible damage to the environment.<br>• An assessment of the risk-weighted consequences of various options. | The Proponent has undertaken comprehensive baseline studies and modelling of aspects of the Proposal that may affect the environment.<br>Where significant potential environmental impacts were identified, measures have been, and will continue to be, incorporated into Proposal design and management to avoid or minimise these potential environmental impacts. |
| **2. Intergenerational equity**<br>The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations. | The Rio Tinto Iron Ore HSECQ Policy incorporates the principle of sustainable development and includes the following commitments:<br>• Prioritising research and implementation programs through technology to reduce impacts to land, enhancing our contribution to biodiversity and improving our efficiency in water and energy use.<br>• Identifying climate change improvement solutions through dedicated optimisation work programs.<br>• Contributing to the health and well-being of local communities. |
| **3. Conservation of biological diversity and ecological integrity.**<br>Conservation of biological diversity and ecological integrity should be a fundamental consideration. | Biological investigations are undertaken by the Proponent during the Proposal planning process to identify aspects of the environment that are of conservation significance. Where significant potential environmental impacts are identified, measures have been, and will continue to be, incorporated into Proposal design and management to avoid or minimise these impacts where practical.<br>The Rio Tinto HSEQ Management System has well established rehabilitation procedures for restoring disturbed environments. |

| Principle | Consideration Given in Proposal |
|---|---|
| **4. Improved valuation, pricing and incentive mechanisms**<br>• Environmental factors should be included in the valuation of assets and services.<br>• The polluter pays principle – those who generate pollution and waste should bear the cost of containment, avoidance or abatement.<br>• The users of goods and services should pay prices based on the full life cycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any wastes.<br>• Environmental goals, having been established, should be pursued in the most cost-effective way, by establishing incentives structures, including market mechanisms, which enable those best placed to maximise benefits and/or minimise costs to develop their own solutions and responses to environmental problems. | Environmental factors have been considered during the design phase of the Proposal, and will continue to be considered during the operational and closure phases of the Proposal.<br>Proposal design and operational management will continue to investigate and implement opportunities to reduce impact to land, and improve efficiency in water and energy use, in accordance with the Rio Tinto Iron Ore Group HSECQ Policy. |
| **5. Waste minimisation**<br>All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment. | All reasonable and practicable measures are taken to minimise the generation of waste and its discharge into the environment through the existing EMP and procedures. |

## 13.2 PRINCIPLES OF EIA FOR THE PROPONENT

Table 13-2 outlines the principles of EIA as described in clause 5 of the 2012 Administrative Procedures.

**Table 13-2: Principles of EIA for the Proponent**

| The principles of EIA for the Proponent | | Discussed in the Document |
|---|---|---|
| 1. | Consult with all stakeholders, including the EPA, DMAs, other relevant government agencies and the local community as early as possible in the planning of their proposal, during the environmental review and assessment of their proposal, and where necessary during the life of the project. | Table 3-1 details the stakeholder consultation undertaken to date. The Proponent will continue to consult with relevant stakeholders throughout the environmental approval process. |
| 2. | Ensure the public is provided with sufficient information relevant to the EIA of a proposal to be able to make informed comment, prior to the EPA completing the assessment report. | This EIA has been prepared to provide sufficient information about the Proposal, its potential environmental impacts and proposed management measures. |

| The principles of EIA for the Proponent | | Discussed in the Document |
|---|---|---|
| 3. | Use best practicable measures and genuine evaluation of options or alternatives in locating, planning and designing their proposal to mitigate detrimental environmental impacts and to facilitate positive environmental outcomes and a continuous improvement approach to environmental management. | Avoiding and minimising impacts to the environment where practical is a key management commitment for the Proposal, and has been implemented during Proposal design. For example, the Proposal has been designed to avoid extensive areas of conservation significant vegetation (PEC) and significant fauna habitat (potential Ghost Bat maternity cave AA1).<br>As detailed in Section 4.3, continuous improvement is a key aspect of the Rio Tinto Iron Ore (WA) HSEQ Management System. |
| 4. | Identify the environmental factors likely to be impacted and the aspects likely to cause impacts in the early stages of planning for their proposal. The onus is on the proponent through the EIA process to demonstrate that the unavoidable impacts will meet the EPA objectives for environmental factors and therefore their proposal is environmentally acceptable. | Table 5-3, Table 6-2, Table 7-1 and Table 8-2 identify the key environmental factors relevant to the Proposal, potential environmental impacts, proposed management measures, and how the EPA objectives relevant to each environmental factor can be met.<br>Table 9-1 provides a brief EIA of the Proposal for other environmental factors. |
| 5. | Consider the following, during project planning and discussions with the EPA, regarding the form, content and timing of their environmental review:<br>a. The activities, investigations (and consequent authorisations) required to undertake the environmental review.<br>b. The efficacy of the investigations to produce sound scientific baseline data about the receiving environment.<br>c. The documentation and reporting of investigations.<br>d. The likely timeframes in which to complete the environmental review;<br>e. Use best endeavours to meet assessment timelines. | The Proponent plans to discuss any concerns once OEPA have had an opportunity to review the Proposal. The content of this environmental review will incorporate advice provided by the OEPA.<br>Comprehensive studies have been undertaken to support the environmental review, and are provided as appendices.<br>Project design has considered the expected timeframes for completion of supporting studies, environmental review preparation and assessment, and timings for key milestones are regularly discussed with the OEPA. |
| 6. | Identify in their environmental review, subject to EPA guidance:<br>a. Best practicable measures to avoid, where possible, and otherwise minimise, rectify, reduce, monitor and manage impacts on the environment.<br>b. Responsible corporate environmental policies, strategies and management practices, which demonstrate how the proposal can be implemented to meet the EPA environmental objectives for environmental factors. | Table 5-3, Table 6-2, Table 7-1 and Table 8-2 identify key management measures to avoid where possible, and otherwise minimise impacts on the environment.<br>These tables also provide an assessment of how the Proposal meets EPA environmental objectives for relevant environmental factors, based on implementation of key management measures, and corporate environmental policies. |

## 13.3 CRITERIA FOR API CATEGORY A

Clause 10.1.1 in the 2012 Administrative Procedures states that the OEPA applies an API-A level of assessment where the proponent has provided sufficient information about the proposal, its environmental impacts, proposed management, and it appears that the proposal is consistent with Category A criteria. Consistency of the Proposal with these criteria is addressed in Table 13-3.

**Table 13-3: Criteria for API Category A**

| Category A Criteria | Discussion |
|---|---|
| The proposal raises a limited number of key environmental factors that can be readily managed and for which there is an established condition-setting framework. | The Proposal raises four key environmental factors:<br>• flora and vegetation;<br>• terrestrial fauna;<br>• hydrological processes (surface water); and<br>• rehabilitation and closure.<br><br>These are assessed in Table 5-3, Table 6-2, Table 7-1 and Table 8-2 respectively.<br><br>These factors are typical of iron ore mining in the Pilbara and can be readily managed under the existing conditions of the MS 970, the existing EMP and other regulatory approvals. |
| The proposal is consistent with established environmental policies, guidelines and standards. | The Proposal is consistent with established environmental policies, guidelines and standards. |
| The proponent can demonstrate that it has conducted appropriate and effective stakeholder consultation, in particular with DMAs. | Stakeholder consultation has been, and will continue to be undertaken throughout the approvals process.<br><br>Section 3 details the stakeholder consultation that has been undertaken to date, issues raised, and Proponent response to issues raised. |
| There is limited or local concern only about the likely effect of the proposal, if implemented, on the environment. | The location of West Angelas is very remote, with no neighbouring mining or pastoral activities. The nearest town, Newman, is located approximately 130 km south-east of West Angelas. |

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# APPENDICES

The following supporting documents are attached to this Environmental Review Document:

Appendix 1 S38 Referral Form

Appendix 2 Ministerial Statement 970

Appendix 3 Proposed New Ministerial Statement

The following supporting documents are contained on CD_ROM inside the back cover of this Environmental Review Document:

Appendix 4 Greater West Angelas Vegetation and Flora Assessment (*ecologia* 2013)

Appendix 5 Greater West Angelas Terrestrial Fauna Assessment (*ecologia* 2014)

Appendix 6 West Angelas Deposit B and F Ghost Bat Assessment (Biologic 2014)

Appendix 7 Environmental Management Program 2014

Appendix 8 West Angelas Closure Plan 2014

Appendix 9 West Angelas Deposits A west and F Subterranean Fauna Assessment November 2014

**Appendix 1**
Section 38 Referral Form

Environmental Protection Authority

GOVERNMENT OF WESTERN AUSTRALIA

EPA REFERRAL FORM PROPONENT

# Referral of a Proposal by the Proponent to the Environmental Protection Authority under Section 38(1) of the *Environmental Protection Act 1986*.

## PURPOSE OF THIS FORM

Section 38(1) of the *Environmental Protection Act 1986* (EP Act) provides that where a development proposal is likely to have a significant effect on the environment, a proponent may refer the proposal to the Environmental Protection Authority (EPA) for a decision on whether or not it requires assessment under the EP Act. This form sets out the information requirements for the referral of a proposal by a proponent.

Proponents are encouraged to familiarise themselves with the EPA's *General Guide on Referral of Proposals* [see Environmental Impact Assessment/Referral of Proposals and Schemes] before completing this form.

A referral under section 38(1) of the EP Act by a proponent to the EPA must be made on this form. A request to the EPA for a declaration under section 39B (derived proposal) must be made on this form. This form will be treated as a referral provided all information required by Part A has been included and all information requested by Part B has been provided to the extent that it is pertinent to the proposal being referred. Referral documents are to be submitted in two formats – hard copy and electronic copy. The electronic copy of the referral will be provided for public comment for a period of 7 days, prior to the EPA making its decision on whether or not to assess the proposal.

## CHECKLIST

Before you submit this form, please check that you have:

| | Yes | No |
|---|---|---|
| Completed all the questions in Part A (essential). | ✓ | |
| Completed all applicable questions in Part B. | ✓ | |
| Included Attachment 1 – location maps. | ✓ | |
| Included Attachment 2 – additional document(s) the proponent wishes to provide (if applicable). | ✓ | |
| Included Attachment 3 – confidential information (if applicable). | | |
| Enclosed an electronic copy of all referral information, including spatial data and contextual mapping but excluding confidential information. | ✓ | |

Following a review of the information presented in this form, please consider the following question (a response is optional).

| Do you consider the proposal requires formal environmental impact assessment? | | |
|---|---|---|
| ☒ Yes | ☐ No | ☐ Not sure |
| If yes, what level of assessment? | | |
| ☒ Assessment on Proponent Information | ☐ Public Environmental Review | |

**PROPONENT DECLARATION** (to be completed by the proponent)

I, Clayton Walker, declare that I am authorised on behalf of Robe River Mining Co. Pty. Ltd to submit this form and further declare that the information contained in this form is true and not misleading.

| | |
|---|---|
| Signature:  | Name (print): Clayton Walker |
| Position: Director | Company: Robe River Mining Co. Pty. Ltd. |
| Date: 5 December 2014 | |

## PART A - PROPONENT AND PROPOSAL INFORMATION

(All fields of Part A must be completed for this document to be treated as a referral)

## 1 PROPONENT AND PROPOSAL INFORMATION

### 1.1 Proponent

| | |
|---|---|
| Name | Robe River Mining Co. Pty. Ltd. |
| Joint Venture parties (if applicable) | Robe River Joint Venture Participants |
| Australian Company Number (if applicable) | 71 008 694 246 |
| Postal Address<br>(where the proponent is a corporation or an association of persons, whether incorporated or not, the postal address is that of the principal place of business or of the principal office in the State) | GPO Box A42<br>Perth WA 6837 |
| Key proponent contact for the proposal:<br>• name<br>• address<br>• phone<br>• email | Carly Nixon<br>Environmental Approvals Specialist<br>GPO Box A42<br>Perth WA 6837<br>T: +61 (08) 6213 1297<br>carly.nixon@riotinto.com |
| Consultant for the proposal (if applicable):<br>• name<br>• address<br>• phone<br>• email | NA |

### 1.2 Proposal

| | |
|---|---|
| Title | West Angelas Deposit A west and Deposit F Revised Proposal. |
| Description | The Proponent, Robe River Mining Co. Pty. Ltd., on behalf of the Robe River Joint Venture Participants, proposes to mine iron ore from above and below the water table at Deposits A west and F, as satellite deposits to the existing West Angelas mining operations. Once mined, ore will be transported by haul trucks to existing processing facilities. |
| Extent (area) of proposed ground disturbance. | The Proposal will require clearing of approximately 3,220 ha.<br><br>This referral is not seeking approval for activities already authorised as part of the existing operations. |

| | |
|---|---|
| Timeframe in which the activity or development is proposed to occur (including start and finish dates where applicable). | Production commenced at the existing West Angelas mining operations in 2001 at Deposit A and in 2011 at Deposit E. Deposit A provides the primary ore source with Deposit E supplementing the production to maintain the current production rate. Deposit B is the next major ore source with mining scheduled to commence in 2015. Production from all existing deposits will decline from 2016. An additional ore source is therefore required to sustain current production from the West Angelas Project. Deposits A west and F have been identified as the next to be developed in the conceptual long term development strategy.<br><br>Robe proposes to commence mining of Deposits A west and F in 2016. |
| Details of any staging of the proposal. | The Proposal is not staged. |
| Is the proposal a strategic proposal? | No. |
| Is the proponent requesting a declaration that the proposal is a derived proposal? | No. |
| Please indicate whether, and in what way, the proposal is related to other proposals in the region. | Deposits A west and F will be developed as satellite deposits to the existing West Angelas mining operations. |
| Does the proponent own the land on which the proposal is to be established? If not, what other arrangements have been established to access the land? | The West Angelas Iron Ore Mine is located on Mineral Lease 248SA (AML248SA) which was granted in 1976 under the *Iron Ore (Robe River) Agreement Act 1964*. The infrastructure associated with the West Angelas mining operations is located on a number of Miscellaneous Licences and General Purpose Leases that were granted under the *Mining Act 1978*. The Leases are held under the Robe River Joint Venture which is managed on behalf of the partners by Robe River Mining Co. Pty. Ltd.<br><br>The current tenure is appropriate tenure for all current and proposed mining activities and mining related infrastructure. |
| What is the current land use on the property, and the extent (area in hectares) of the property? | The location of West Angelas is very remote, with no neighbouring mining or pastoral activities. |

## 1.3 Location

| | |
|---|---|
| Name of the Shire in which the proposal is located. | The Proposal is located in the Shire of East Pilbara. |
| For urban areas:<br>• street address;<br>• lot number;<br>• suburb; and<br>• nearest road intersection. | NA. |
| For remote localities:<br>• nearest town; and<br>• distance and direction from that town to the proposal site. | The West Angelas Iron Ore Mine is located approximately 130 kilometres (km) northwest of Newman in the Pilbara region of Western Australia. |
| Electronic copy of spatial data - GIS or CAD, geo-referenced and conforming to the following parameters:<br>• GIS: polygons representing all activities and named;<br>• CAD: simple closed polygons representing all activities and named;<br>• datum: GDA94;<br>• projection: Geographic (latitude/longitude) or Map Grid of Australia (MGA);<br>• format: Arcview shapefile, Arcinfo coverages, Microstation or AutoCAD. | Enclosed?: **Yes.** |

## 1.4 Confidential Information

| | |
|---|---|
| Does the proponent wish to request the EPA to allow any part of the referral information to be treated as confidential? | No. |
| If yes, is confidential information attached as a separate document in hard copy? | NA. |

## 1.5 Government Approvals

| | | | |
|---|---|---|---|
| Is rezoning of any land required before the proposal can be implemented?<br>If yes, please provide details. | | No. | |
| Is approval required from any Commonwealth or State Government agency or Local Authority for any part of the proposal?<br>If yes, please complete the table below. | | Yes. | |
| Agency/Authority | Approval required | Application lodged Yes / No | Agency/Local Authority contact(s) for proposal |

| | | | |
|---|---|---|---|
| Minister for Environment; Environmental Protection Authority<br>(EPA) | *Environmental Protection Act 1986* (WA) - Part IV: Ministerial Statement | Purpose of this document | EPA<br>The Atrium<br>168 St Georges Tce<br>PERTH WA 6000 |
| Department of Water<br>(DoW) | *Rights in Water and Irrigation Act 1914 (WA):* Licenses to Construct Wells and Take Water | No | DoW<br>The Atrium<br>168 St Georges Tce<br>PERTH WA 6000 |

## PART B - ENVIRONMENTAL IMPACTS AND PROPOSED MANAGEMENT

### 2. ENVIRONMENTAL IMPACTS

Describe the impacts of the proposal on the following elements of the environment, by answering the questions contained in Sections 2.1-2.11:

2.1 flora and vegetation;

2.2 fauna;

2.3 rivers, creeks, wetlands and estuaries;

2.4 significant areas and/ or land features;

2.5 coastal zone areas;

2.6 marine areas and biota;

2.7 water supply and drainage catchments;

2.8 pollution;

2.9 greenhouse gas emissions;

2.10 contamination; and

2.11 social surroundings.

These features should be shown on the site plan, where appropriate.

For all information, please indicate:

(a) the source of the information; and

(b) the currency of the information.

### 2.1 Flora and Vegetation

2.1.1 Do you propose to clear any native flora and vegetation as a part of this proposal?

[A proposal to clear native vegetation may require a clearing permit under Part V of the EP Act (Environmental Protection (Clearing of Native Vegetation) Regulations 2004)]. Please contact the Department of Environment and Conservation (DEC) for more information.

(please tick) ☒ Yes **If yes**, complete the rest of this section.

☐ No **If no**, go to the next section

2.1.2 How much vegetation are you proposing to clear (in hectares)?

The Proposal will require clearing of approximately 3,220 hectares (ha).

This proposed clearing is comprised of the following components: clearing for mining will be increased by 920 ha, from 2,260 ha to 3,180 ha; clearing for waste dumps will be increased by approximately 1,853 ha, from 1,407 ha to 3,260 ha; and clearing for infrastructure will be increased by 450 ha, from 1,000 ha to 1,450 ha.

2.1.3 Have you submitted an application to clear native vegetation to the DEC (unless you are exempt from such a requirement)?

☐ Yes ☒ No **If yes**, on what date and to which office was the application submitted of the DEC?

The clearing required for this Proposal is the subject of this application.

2.1.4 Are you aware of any recent flora surveys carried out over the area to be disturbed by this proposal?

☒ Yes ☐ No **If yes**, please attach a copy of any related survey reports and provide the date and name of persons / companies involved in the survey(s).

**If no**, please do not arrange to have any biological surveys conducted prior to consulting with the DEC.

Refer to Section 5 of the Environmental Review Document.

2.1.5 Has a search of DEC records for known occurrences of rare or priority flora or threatened ecological communities been conducted for the site?

☒ Yes ☐ No If you are proposing to clear native vegetation for any part of your proposal, a search of DEC records of known occurrences of rare or priority flora and threatened ecological communities will be required. Please contact DEC for more information.

A search of Department of Parks and Wildlife (DPaW) records was undertaken as part of the vegetation and flora assessment undertaken by *ecologia*.

2.1.6 Are there any known occurrences of rare or priority flora or threatened ecological communities on the site?

☒ Yes ☐ No **If yes**, please indicate which species or communities are involved and provide copies of any correspondence with DEC regarding these matters.

The Priority 1; West Angelas Cracking-Clay Priority Ecological Community (**PEC**) occurs extensively within the area. This community is defined as 'open tussock grasslands of *Astrebla pectinata*, *A. elymoides*, *Aristida latifolia* in combination with *Astrebla squarrosa* and low scattered shrubs of *Sida fibulifera*, on basalt derived cracking-clay loam depressions and flowlines'. Threats to this community include; clearing for further mining expansion and future infrastructure development, weed invasion and changes in fire regimes.

The West Angelas Cracking Clay PEC is not proposed to be detrimentally impacted by the Proposal.

Nine Priority Flora records are considered to be of relevance to the Proposal:

- *Aristida jerichoensis* var. *subspinulifera* (Priority (**P**) 1);
- *Brachyscome* sp. Wanna Munna Flats (S. van Leeuwen 4662) (P1);
- *Brunonia* sp. long hairs (D.E. Symon 2440) (P1);
- *Aristida lazaridis* (P2);
- *Indigofera gilesii* subsp. *gilesii* (P3);
- *Themeda* sp. Hamersley Station (M.E. Trudgen 11431) (P3);
- *Triodia* sp. Mt Ella (M.E. Trudgen 12739) (P3);
- *Rhagodia* sp. Hamersley (M. Trudgen 17794) (P3); and
- *Goodenia nuda* (P4).

Refer to Section 5 of the Environmental Review Document.

2.1.7 If located within the Perth Metropolitan Region, is the proposed development within or adjacent to a listed Bush Forever Site? (You will need to contact the Bush Forever Office, at the Department for Planning and Infrastructure)

☐ Yes ☐ No **If yes**, please indicate which Bush Forever Site is affected (site number and name of site where appropriate).

Not applicable.

2.1.8 What is the condition of the vegetation at the site?

West Angelas is not located within a pastoral lease and, as a result, is not actively grazed. Subsequently, the vegetation condition was assessed to be in very good to excellent condition despite evidence of weed invasion.

Refer to Section 5 of the Environmental Review Document.

## 2.2 Fauna

2.2.1 Do you expect that any fauna or fauna habitat will be impacted by the proposal?

(please tick) ☒ Yes **If yes**, complete the rest of this section.

☐ No **If no**, go to the next section.

2.2.2 Describe the nature and extent of the expected impact.

The Proposal will result in the clearing of up to 3,220 ha of potential fauna habitat, therefore habitat loss is likely to be the biggest threat to fauna, including several conservation significant fauna species (namely: Fork-tailed Swift, the Western Pebble-mound Mouse, the Short-tailed Mouse, the Ghost Bat, the Bush Stone-curlew and the Australian Bustard).

2.2.3 Are you aware of any recent fauna surveys carried out over the area to be disturbed by this proposal?

☒ Yes ☐ No **If yes**, please attach a copy of any related survey reports and provide the date and name of persons / companies involved in the survey(s).

**If no**, please do not arrange to have any biological surveys conducted prior to consulting with the DEC.

Refer to Section 6 of the Environmental Review Document.

2.2.4 Has a search of DEC records for known occurrences of Specially Protected (threatened) fauna been conducted for the site?

☒ Yes ☐ No (please tick)

A search of DPaW records was undertaken as part of the terrestrial fauna assessment undertaken by *ecologia*.

2.2.5 Are there any known occurrences of Specially Protected (threatened) fauna on the site?

☒ Yes ☐ No **If yes**, please indicate which species or communities are involved and provide copies of any correspondence with DEC regarding these matters.

Six conservation significant species recorded or assessed as having a high likelihood of occurrence are considered to be of relevance to the Proposal:

- Fork-tailed Swift, *Apus pacificus* (EPBC M, WC Act S3);
- Western Pebble-mound Mouse, *Pseudomys chapmani* (DPaW P4);
- Short-tailed Mouse, *Leggadina lakedownensis* (DPaW P4);
- Ghost Bat, *Macroderma gigas* (DPaW P4);
- Bush Stone-curlew, *Burhinus grallarius* (DPaW P4); and
- Australian Bustard, *Ardeotis australis* (DPaW P4).

The presence of the Ghost Bat represents the most significant faunal finding. Populations of this species are known from a series of roost caves in the region including the potential maternity cave; AA1 near Deposit F.

Refer to Section 6 of the Environmental Review Document.

### 2.3 Rivers, Creeks, Wetlands and Estuaries

2.3.1 Will the development occur within 200 metres of a river, creek, wetland or estuary?

(please tick) ☒ Yes **If yes**, complete the rest of this section.

☐ No **If no**, go to the next section.

2.3.2 Will the development result in the clearing of vegetation within the 200 metre zone?

☐ Yes ☒ No **If yes**, please describe the extent of the expected impact.

2.3.3 Will the development result in the filling or excavation of a river, creek, wetland or estuary?

☒ Yes ☐ No **If yes**, please describe the extent of the expected impact.

Deposit F is located within the same valley as an ephemeral unnamed tributary, hereafter referred to as central creek.

Central creek will be intercepted immediately upstream of Deposit F.

2.3.4 Will the development result in the impoundment of a river, creek, wetland or estuary?

☒ Yes ☐ No **If yes**, please describe the extent of the expected impact.

Deposit F, Pit F2 naturally intercepts central creek. A 2% AEP capacity diversion channel is proposed to divert the creek upstream of the F2 pit eastwards across the catchment divide into the adjacent Weeli Wolli catchment. No viable alternative option exists to continue the flow of this creek within its natural catchment.

Refer to Section 7 of the Environmental Review Document.

2.3.5 Will the development result in draining to a river, creek, wetland or estuary?

☐ Yes ☒ No **If yes**, please describe the extent of the expected impact.

2.3.6 Are you aware if the proposal will impact on a river, creek, wetland or estuary (or its buffer) within one of the following categories? (please tick)

| | | | |
|---|---|---|---|
| Conservation Category Wetland | ☐ Yes | ✓ No | ☐ Unsure |
| Environmental Protection (South West Agricultural Zone Wetlands) Policy 1998 | ☐ Yes | ✓ No | ☐ Unsure |
| Perth's Bush Forever site | ☐ Yes | ✓ No | ☐ Unsure |
| Environmental Protection (Swan & Canning Rivers) Policy 1998 | ☐ Yes | ✓ No | ☐ Unsure |
| The management area as defined in s4(1) of the *Swan River Trust Act 1988* | ☐ Yes | ✓ No | ☐ Unsure |
| Which is subject to an international agreement, because of the importance of the wetland for waterbirds and waterbird habitats (e.g. Ramsar, JAMBA, CAMBA) | ☐ Yes | ✓ No | ☐ Unsure |

## 2.4 Significant Areas and/ or Land Features

2.4.1 Is the proposed development located within or adjacent to an existing or proposed National Park or Nature Reserve?

☐ Yes ☒ No **If yes**, please provide details.

The Proposal is located approximately 20 km from the nearest boundary of the Karijini National Park.

2.4.2 Are you aware of any Environmentally Sensitive Areas (as declared by the Minister under section 51B of the EP Act) that will be impacted by the proposed development?

☐ Yes ☒ No **If yes**, please provide details.

2.4.3 Are you aware of any significant natural land features (e.g. caves, ranges etc) that will be impacted by the proposed development?

☐ Yes ☒ No **If yes**, please provide details.

## 2.5 Coastal Zone Areas (Coastal Dunes and Beaches)

2.5.1 Will the development occur within 300metres of a coastal area?

(please tick) ☐ Yes **If yes**, complete the rest of this section.

☒ No **If no**, go to the next section.

2.5.2 What is the expected setback of the development from the high tide level and from the primary dune?

2.5.3 Will the development impact on coastal areas with significant landforms including beach ridge plain, cuspate headland, coastal dunes or karst?

☐ Yes ☐ No **If yes**, please describe the extent of the expected impact.

2.5.4 Is the development likely to impact on mangroves?

☐ Yes ☐ No **If yes**, please describe the extent of the expected impact.

## 2.6 Marine Areas and Biota

2.6.1 Is the development likely to impact on an area of sensitive benthic communities, such as seagrasses, coral reefs or mangroves?

☐ Yes ☒ No **If yes**, please describe the extent of the expected impact.

2.6.2 Is the development likely to impact on marine conservation reserves or areas recommended for reservation (as described in *A Representative Marine Reserve System for Western Australia*, CALM, 1994)?

☐ Yes ☒ No **If yes**, please describe the extent of the expected impact.

2.6.3 Is the development likely to impact on marine areas used extensively for recreation or for commercial fishing activities?

☐ Yes ☒ No **If yes**, please describe the extent of the expected impact, and provide any written advice from relevant agencies (e.g. Fisheries WA).

## 2.7 Water Supply and Drainage Catchments

2.7.1 Are you in a proclaimed or proposed groundwater or surface water protection area?

(You may need to contact the Department of Water (DoW) for more information on the requirements for your location, including the requirement for licences for water abstraction. Also, refer to the DoW website)

☒ Yes ☐ No **If yes**, please describe what category of area.

The Proposal is located within the Pilbara Groundwater Area proclaimed under the *Rights in Water and Irrigation Act 1914*.

2.7.2 Are you in an existing or proposed Underground Water Supply and Pollution Control area?

(You may need to contact the DoW for more information on the requirements for your location, including the requirement for licences for water abstraction. Also, refer to the DoW website)

☐ Yes ☒ No **If yes**, please describe what category of area.

2.7.3 Are you in a Public Drinking Water Supply Area (PDWSA)?

(You may need to contact the DoW for more information or refer to the DoW website. A proposal to clear vegetation within a PDWSA requires approval from DoW.)

☐ Yes ☒ No **If yes**, please describe what category of area.

2.7.4 Is there sufficient water available for the proposal?

(Please consult with the DoW as to whether approvals are required to source water as you propose. Where necessary, please provide a letter of intent from the DoW)

☒ Yes ☐ No (please tick)

2.7.5 Will the proposal require drainage of the land?

☐ Yes ☒ No **If yes**, how is the site to be drained and will the drainage be connected to an existing Local Authority or Water Corporation drainage system? Please provide details.

2.7.6 Is there a water requirement for the construction and/ or operation of this proposal?

(please tick) ☒ Yes **If yes**, complete the rest of this section.

☐ No **If no**, go to the next section.

2.7.7 What is the water requirement for the construction and operation of this proposal, in kilolitres per year?

West Angelas is considered to be a water neutral (to small deficit) site in terms of water balance; operational water demand is roughly equivalent to dewatering requirements. While the site as a whole is water neutral, the water management of each deposit is different with some in deficit and others in surplus. Water sources are integrated to ensure continuity of supply across West Angelas. This integrated water management strategy will continue to be implemented to address water supply and demand requirements for the Revised Proposal.

Refer to Section 9 of the Environmental Review Document.

2.7.8 What is the proposed source of water for the proposal? (e.g. dam, bore, surface water etc.)

Dewatering water is used on-site in the first instance to supply water for operational purposes (processing and dust suppression).

The Turee Creek B Borefield is used to provide potable water to the mine and camp facilities and, when required, water for processing purposes and dust suppression.

## 2.8 Pollution

2.8.1 Is there likely to be any discharge of pollutants from this development, such as noise, vibration, gaseous emissions, dust, liquid effluent, solid waste or other pollutants?

(please tick) ☒ Yes **If yes**, complete the rest of this section.

☐ No **If no**, go to the next section.

2.8.2 Is the proposal a prescribed premise, under the Environmental Protection Regulations 1987?

(Refer to the EPA's *General Guide for Referral of Proposals to the EPA under section 38(1) of the EP Act 1986* for more information)

☒ Yes ☐ No **If yes**, please describe what category of prescribed premise.

The Proposal is a Prescribed Premise 'by association' since it is covered by the existing West Angelas Operating Licence L7774/2000. The licence allows Category 5, 6, 63, 64, 73 and 85 activities at West Angelas.

2.8.3 Will the proposal result in gaseous emissions to air?

☒ Yes ☐ No **If yes**, please briefly describe.

The Proposal will generate Greenhouse Gas (GHG) emissions.

2.8.4 Have you done any modelling or analysis to demonstrate that air quality standards will be met, including consideration of cumulative impacts from other emission sources?

☐ Yes ☒ No **If yes**, please briefly describe.

No modelling of projected emissions was undertaken as emissions generated by the Proposal are not expected to be greater than or different to those from existing operations.

Emissions have been, and will continue to be, managed under the existing operating licence, the *Clean Energy Act 2011* (Cwth) and the *National Greenhouse and Energy Reporting Act 2007* (Cwth).

2.8.5 Will the proposal result in liquid effluent discharge?

☐ Yes ☒ No **If yes**, please briefly describe the nature, concentrations and receiving environment.

2.8.6 If there is likely to be discharges to a watercourse or marine environment, has any analysis been done to demonstrate that the State Water Quality Management Strategy or other appropriate standards will be able to be met?

☐ Yes ☒ No **If yes**, please describe.

2.8.7 Will the proposal produce or result in solid wastes?

☒ Yes ☐ No **If yes**, please briefly describe the nature, concentrations and disposal location/ method.

Waste rock will be transported by haul trucks to external waste dumps according to the material categorisation. Where practicable, waste may also be used in progressive backfilling of the pits to assist in achieving closure objectives for the site.

Refer to Section 8 of the Environmental Review Document.

2.8.8 Will the proposal result in significant off-site noise emissions?

☐ Yes ☒ No **If yes**, please briefly describe.

Noise emissions are not expected to be significantly greater than or different to those of existing operations.

2.8.9 Will the development be subject to the Environmental Protection (Noise) Regulations 1997?

☒ Yes ☐ No **If yes**, has any analysis been carried out to demonstrate that the proposal will comply with the Regulations?

Please attach the analysis.

Noise emissions will be managed under the Environmental Protection (Noise) Regulations 1997. However, previous Noise Assessments have shown that noise levels at the only sensitive receptor, the village, will not exceed Environmental Protection (Noise) Regulation thresholds.

2.8.10 Does the proposal have the potential to generate off-site, air quality impacts, dust, odour or another pollutant that may affect the amenity of residents and other "sensitive premises" such as schools and hospitals (proposals in this category may include intensive agriculture, aquaculture, marinas, mines and quarries etc.)?

☐ Yes ☒ No **If yes**, please describe and provide the distance to residences and other "sensitive premises".

The location of West Angelas is very remote, with no neighbouring mining or pastoral activities. The nearest town, Newman, is located approximately 130 km south-east of West Angelas. Therefore, impacts on sensitive receptors from nuisance dust, noise or other air quality impacts are expected to be limited.

2.8.11 If the proposal has a residential component or involves "sensitive premises", is it located near a land use that may discharge a pollutant?

☐ Yes ☐ No ☒ Not Applicable

**If yes**, please describe and provide the distance to the potential pollution source

## 2.9 Greenhouse Gas Emissions

2.9.1 Is this proposal likely to result in substantial greenhouse gas emissions (greater than 100 000 tonnes per annum of carbon dioxide equivalent emissions)?

☐ Yes ☒ No **If yes**, please provide an estimate of the annual gross emissions in absolute and in carbon dioxide equivalent figures.

West Angelas is seen as a relatively small emitter of GHG.

2.9.2 Further, if yes, please describe proposed measures to minimise emissions, and any sink enhancement actions proposed to offset emissions.

## 2.10 Contamination

2.10.1 Has the property on which the proposal is to be located been used in the past for activities which may have caused soil or groundwater contamination?

☒ Yes ☐ No ☐ Unsure **If yes**, please describe.

Deposits A west and F will be developed as satellite deposits to the existing West Angelas mining operations.

2.10.2 Has any assessment been done for soil or groundwater contamination on the site?

☒ Yes ☐ No **If yes**, please describe.

Groundwater sampling and analysis of water quality indicates that the groundwater is of good quality.

Refer to Section 9 of the Environmental Review Document.

2.10.3 Has the site been registered as a contaminated site under the *Contaminated Sites Act 2003*? (on finalisation of the CS Regulations and proclamation of the CS Act)

☐ Yes ☒ No **If yes**, please describe.

## 2.11 Social Surroundings

2.11.1 Is the proposal on a property which contains or is near a site of Aboriginal ethnographic or archaeological significance that may be disturbed?

☒ Yes ☐ No ☐ Unsure **If yes**, please describe.

Archaeological and ethnographic surveys have been undertaken over the majority of the Proposal area. To date no ethnographic sites have been identified. A number of heritage sites have been identified at both Deposits A west and F.

At Deposit A west the majority of the heritage sites include artefact scatters. Based on the current design for Deposit A west, three artefact scatters will be impacted. Section 18 consent will need to be sought for impact to these sites.

At Deposit F the sites identified include rock shelters, scarred trees and artefact scatters. A significant rock shelter containing rock art is located approximately 500m to the north of pit F2.

Based on the current design for Deposit F, one artefact scatter will be directly impacted in pit F2. Three rock shelters within immediate proximity of pit F1 may be affected by indirect impacts as a result of blasting. Additionally, a rock shelter and scarred tree located within vicinity of pit F2 may also be affected by indirect impacts. Section 18 consent for these sites will need to be sought and the rock shelters may require archaeological excavation.

Refer to Section 9 of the Environmental Review Document.

2.11.2 Is the proposal on a property which contains or is near a site of high public interest (e.g. a major recreation area or natural scenic feature)?

☐ Yes ☒ No **If yes**, please describe.

The Proposal is an extension to an existing, very remote mining operation, located within an area where the dominant land uses are pastoral and mining.

There are no significant features that warrant public interest.

2.11.3 Will the proposal result in or require substantial transport of goods, which may affect the amenity of the local area?

☐ Yes ☒ No **If yes**, please describe.

## 3. PROPOSED MANAGEMENT

### 3.1 Principles of Environmental Protection

3.1.1 Have you considered how your project gives attention to the following Principles, as set out in section 4A of the EP Act? (For information on the Principles of Environmental Protection, please see EPA Position Statement No. 7, available on the EPA website)

1. The precautionary principle. ☒ Yes ☐ No
2. The principle of intergenerational equity. ☒ Yes ☐ No
3. The principle of the conservation of biological diversity and ecological integrity. ☒ Yes ☐ No
4. Principles relating to improved valuation, pricing and incentive mechanisms. ☒ Yes ☐ No
5. The principle of waste minimisation. ☒ Yes ☐ No

Refer to Section 13 of the Environmental Review Document

3.1.2 Is the proposal consistent with the EPA's Environmental Protection Bulletins/Position Statements and Environmental Assessment Guidelines/Guidance Statements (available on the EPA website)?

☒ Yes ☐ No

### 3.2 Consultation

3.2.1 Has public consultation taken place (such as with other government agencies, community groups or neighbours), or is it intended that consultation shall take place?

☒ Yes ☐ No **If yes**, please list those consulted and attach comments or summarise response on a separate sheet.

Refer to Section 3 of the Environmental Review Document.

**Appendix 2**
Ministerial Statement 970

**THIS DOCUMENT**

This document has been produced by the Office of the Appeals Convenor as an electronic version of the original Statement for the proposal listed below as signed by the Minister and held by this Office. Whilst every effort is made to ensure its accuracy, no warranty is given as to the accuracy or completeness of this document.

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Published on: 12 June 2014 Statement No: 970

# STATEMENT TO AMEND CONDITIONS APPLYING TO A PROPOSAL (PURSUANT TO THE PROVISIONS OF SECTION 46 OF THE *ENVIRONMENTAL PROTECTION ACT 1986*)

West Angelas Iron Ore Project

**Proposal:** The development of iron ore mines at Deposits 'A', 'B', and 'E', waste dumps, ore processing operation and associated infrastructure at West Angelas, 130 kilometres west of Newman, and rail infrastructure, as documented in Schedule 1 of this Ministerial Statement.

**Proponent:** Robe River Mining Co. Pty. Ltd.

**Proponent Address:** 152-158 St Georges Terrace
PERTH WA 6000
GPO Box A42, PERTH WA 6001

**Assessment Number:** 1914

**Previous Assessment Number:** 1144

**Report of the Environmental Protection Authority:** 1508

**Previous Report of the Environmental Protection Authority:** 924

**Previous Ministerial Statement Number:** 514

The implementation of the proposal to which the above report of the Environmental Protection Authority relates is subject to the following conditions and procedures, which replace and supersede all previous conditions of Ministerial Statement 514.

## 1 Proposal Implementation

1-1 When implementing the proposal, the proponent shall not exceed the authorised extent of the proposal as defined in Column 3 of Table 2 in Schedule 1, unless amendments to the proposal and the authorised extent of the proposal have been approved under the *Environmental Protection Act 1986*.

## 2 Contact Details

2-1 The proponent shall notify the Chief Executive Officer (CEO) of any change of its name, physical address or postal address for the serving of notices or other correspondence within 28 days of such change. Where the proponent is a corporation or an association of persons, whether incorporated or not, the postal address is that of the principal place of business or of the principal office in the State.

## 3 Compliance Reporting

3-1 The proponent shall prepare and maintain a Compliance Assessment Plan to the satisfaction of the CEO.

3-2 The proponent shall submit to the CEO the Compliance Assessment Plan required by condition 3-1 prior to the first Compliance Assessment Report required by condition 3-6.

The Compliance Assessment Plan shall indicate:

(1) the frequency of compliance reporting;

(2) the approach and timing of compliance assessments;

(3) the retention of compliance assessments;

(4) the method of reporting of potential non-compliance and corrective actions to take;

(5) the table of contents of Compliance Assessment Reports; and

(6) public availability of Compliance Assessment Reports.

3-3 The proponent shall assess compliance with conditions in accordance with the Compliance Assessment Plan required by condition 3-1.

3-4 The proponent shall retain reports of all compliance assessments described in the Compliance Assessment Plan required by condition 3-1 and shall make those reports available when requested by the CEO.

3-5 The proponent shall advise the CEO of any potential non-compliance within seven days of that non-compliance being known.

3-6 The proponent shall submit to the CEO Compliance Assessment Reports addressing compliance in the previous calendar year. Compliance Assessment Reports shall be submitted by the submission date defined in the Compliance Assessment Plan required by condition 3-1.

The Compliance Assessment Report shall:

(1) be endorsed by the proponent's Managing Director/ General Manager/ Chief Executive Officer or a person delegated to sign on the Managing Director's/ General Manager's/ Chief Executive Officer's behalf;

(2) include a statement as to whether the proponent has complied with the conditions;

(3) identify all potential non-compliances and describe corrective and preventive actions taken;

(4) be made publicly available in accordance with the approved Compliance Assessment Plan; and

(5) indicate any proposed changes to the Compliance Assessment Plan required by condition 3-1.

## 4 Public Availability of Data

4-1 Subject to condition 4-2, within a reasonable time period, approved by the CEO, of the issue of this statement and for the remainder of the life of the proposal, the proponent shall make publicly available, in a manner approved by the CEO, all validated environmental data (including sampling design, sampling methodologies, empirical data and derived information products (e.g. maps)) relevant to the assessment of this proposal and implementation of this statement.

4-2 If any data referred to in condition 4-1 contains particulars of:

(1) a secret formula or process; or

(2) confidential commercially sensitive information;

the proponent may submit a request for approval from the CEO to not make this data publicly available. In making such a request, the proponent shall provide the CEO with an explanation and reasons why the data should not be made publicly available.

## 5 Environmental Management Program

5-1 The proponent shall implement the proposal in accordance with the "*Environmental Management Program*", dated November 2013, or subsequent revisions approved by the CEO.

The Environmental Management Program consists of the following Management Plans:

(1) Groundwater Management Plan;

(2) Surface Water Management Plan;

(3) Vegetation and Flora Management Plan;

(4) Fauna Management Plan;

(5) Dust Management Plan;

(6) Waste Management Plan; and

(7) Rail Management Plan.

Each Management Plan includes:

i. the specific environmental objectives and targets for each environmental factor;

ii. the management measures to be applied to avoid and minimise the environmental impact of the proposal;

iii. monitoring measures to measure the performance of management against targets; and

iv. contingency measures to mitigate impacts.

5-2 The proponent shall make the Environmental Management Program required by condition 5.1 publicly available, in a manner approved by the CEO.

## 6 Groundwater

6-1 The proponent shall manage groundwater abstraction and dewatering activities to ensure minimal adverse impacts on the availability and quality of groundwater resources and the dependent ecology.

6-2 To verify that the requirements of condition 6-1 are met the proponent shall undertake monitoring of groundwater level elevations and quality as outlined in the Groundwater Management Plan approved as part of Environmental Management Program required by condition 5.

6-3 In the event that the monitoring required by condition 6-2 indicates that the requirements of condition 6-1 are not met, the proponent shall implement contingency actions as outlined in the Groundwater Management Plan.

6-4 The proponent shall submit annually the results of monitoring required by condition 6-2 to the CEO of the Office of the Environmental Protection Authority as part of the compliance assessment reports required by condition 3-6.

## 7 Surface Water Drainage

7-1 The proponent shall manage surface water drainage and discharge to ensure minimal adverse impacts on existing surface water drainage patterns or the water dependent ecosystems.

7-2 To verify that the requirements of condition 7-1 are met, the proponent shall undertake monitoring of the quality and quantity of water discharge as outlined in the Surface Water Management Plan approved as part of the Environmental Management Program required by condition 5.

7-3 In the event that the monitoring required by condition 7-2 indicates that the requirements of condition 7-1 are not met, the proponent shall implement contingency actions as outlined in the Surface Water Management Plan.

7-4 The proponent shall submit annually the results of monitoring required by condition 7-2 to the CEO as part of the Compliance Assessment Reports required by condition 3-6.

## 8 Conservation Significant Communities and Species

8-1 The proponent shall manage clearing activities to ensure minimal adverse impacts on conservation significant communities and species.

8-2 To verify that the requirements of condition 8-1 are met, the proponent shall implement the proposal in accordance with the Vegetation and Flora Management Plan and Fauna Management Plan approved as part of the Environmental Management Program required by condition 5.

8-3 In the event that monitoring required by the Management Plans detailed in condition 8-2 indicates that the specific environmental objectives and targets, identified for each environmental factor, have been exceeded, the proponent shall:

(1) within 7 days of becoming aware of the exceedance, implement contingency measures as outlined in the management plans and continue implementation until environmental objectives and targets are being met, or as otherwise agreed by the CEO; and

(2) within 14 days of becoming aware of the exceedance, submit details of contingency measures implemented to the CEO.

## 9 Rehabilitation and closure

9-1 The proponent shall ensure that the mine is closed, decommissioned and rehabilitated in an ecologically sustainable manner, consistent with agreed post-mining outcomes and land uses, and without unacceptable liability to the State of Western Australia.

9-2 The proponent shall prepare a Mine Closure Plan for the West Angelas Iron Ore Project.

9-3 The Mine Closure Plan required by condition 9-2 shall:

(1) when implemented, manage the implementation of the proposal to meet the requirements of condition 9-1;

(2) be prepared in accordance with the *Guidelines for Preparing Mine Closure Plans*, *June 2011* (Department of Mines and Petroleum and Environmental Protection Authority) or its revisions; and

(3) be to the requirements of the CEO on advice of the Department of Mines and Petroleum.

9-4 Within 12 months of commissioning of additional mine pits or as otherwise agreed by the CEO the proponent shall implement the approved Mine Closure Plan and continue implementation until otherwise agreed by the CEO.

9-5 Revisions to the Mine Closure Plan may be approved by the CEO on the advice of the Department of Mines and Petroleum.

9-6 The proponent shall implement revisions of the Mine Closure Plan required by condition 9-5.

[Signed 11 June 2014]

**HON ALBERT JACOB MLA**
**MINISTER FOR ENVIRONMENT; HERITAGE**

**Schedule 1**

**Table 1: Summary of the Proposal**

| | |
|---|---|
| **Proposal title** | West Angelas Iron Ore Project |
| **Proponent name** | Robe River Mining Co. Pty. Ltd. |
| **Short description** | Development and operation of an open-cut iron ore mine and associated infrastructure at the West Angelas Iron Ore Mine, 130 kilometres west of Newman in the Pilbara region (Figure 1). Iron ore is to be mined from above and below the water table in Deposits A, B and E. The general lay out of the mine and facilities are documented in Figure 2.<br><br>The mining operations are supplied with water from the mine dewatering bores and water from the Turee Creek B Borefield, located approximately 30 kilometres west of the minesite.<br><br>Railway infrastructure from West Angelas to the port facilities at Cape Lambert (Figure 3). |

**Table 2: Location and authorised extent of physical and operational elements**

| **Column 1** | **Column 2** | **Column 3** |
|---|---|---|
| **Element** | **Location** | **Authorised Extent** |
| Mining Area (deposits A, B and E) | Figure 2 | Clearing of no more than 2,260 hectares (ha) within a 19,853 ha development envelope. |
| Waste Dumps | Figure 2 | Clearing of no more than 1,407 ha within a 19,853 ha development envelope. |
| Associated infrastructure, access and accommodation | Figure 2 | Clearing of no more than 1,000 ha within a 19,853 ha development envelope. |

**Figures (attached)**

Figure 1 – Regional Location of West Angelas

Figure 2 – West Angelas Iron Ore Mine Indicative Layout and Approval Outline

Figure 3 – West Angelas Railway

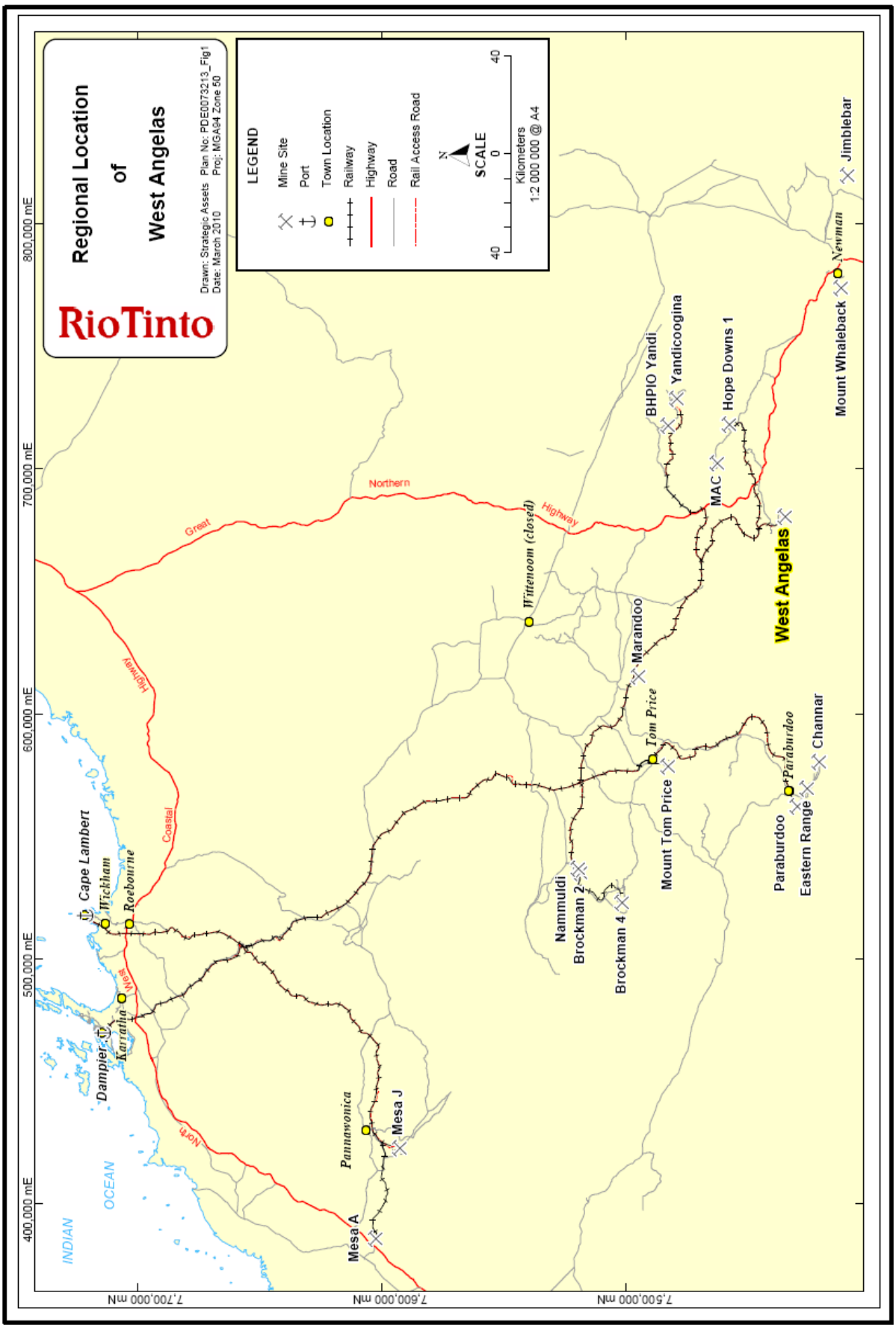



Figure 1: Regional Location of West Angelas

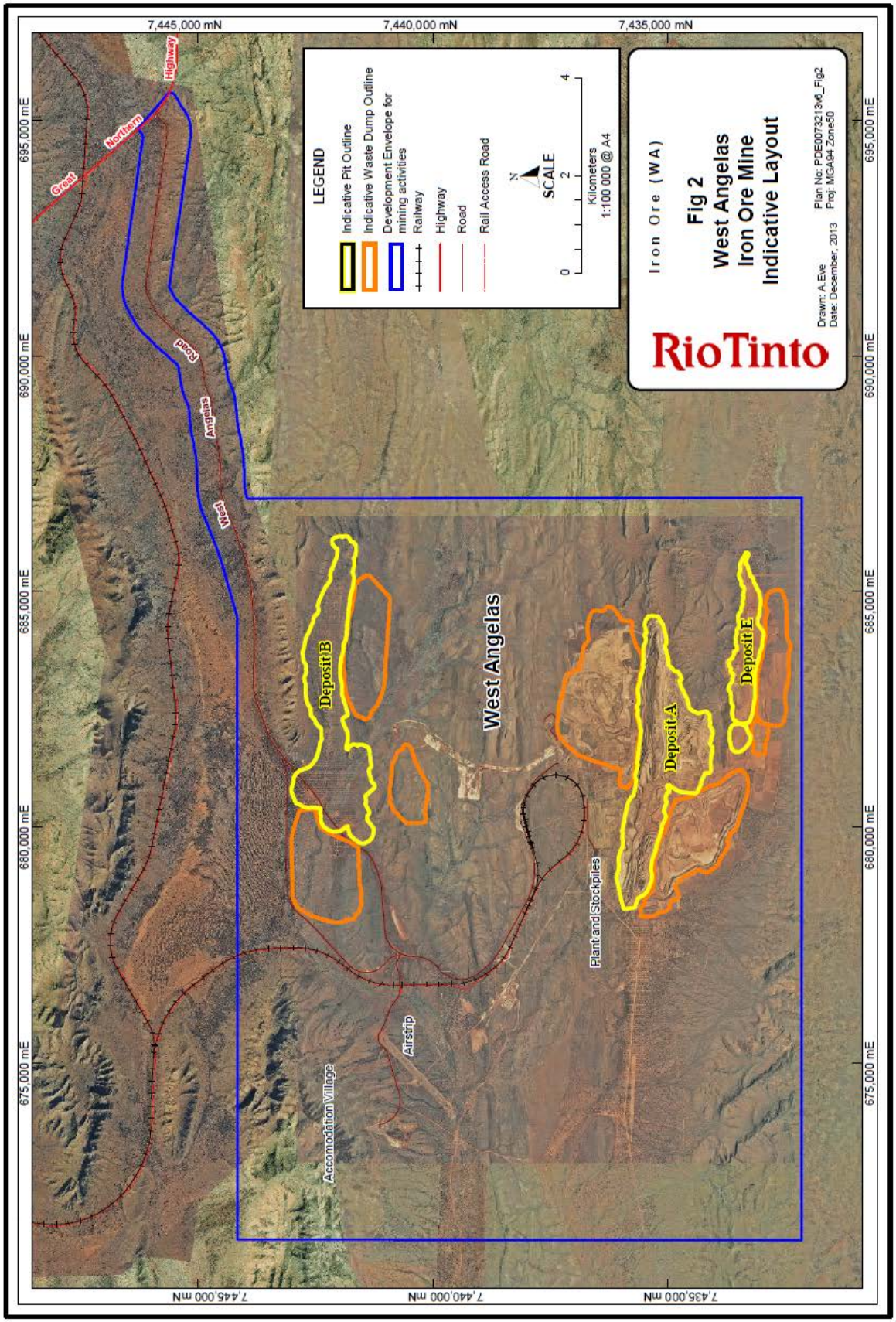



Figure 2: West Angelas Iron Ore Mine Development Envelope and Indicative Layout

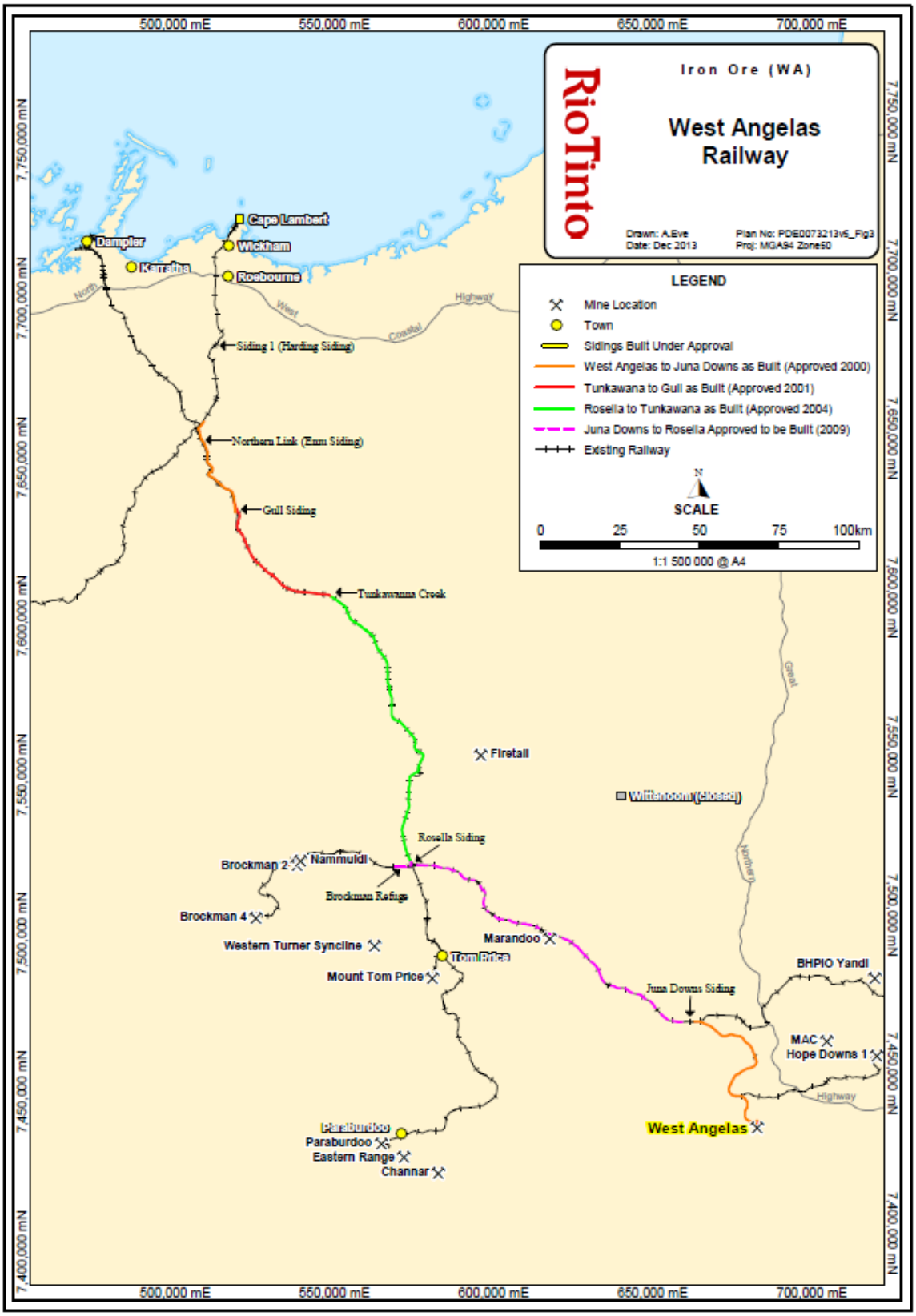



Figure 3: West Angelas Railway

**Schedule 2**

## West Angelas Iron Ore Project

Coordinates defining the development envelope are held by the Office of the Environmental Protection Authority, dated 31 December 2013.

**Schedule 3**

## Notes

The following notes are provided for information and do not form a part of the implementation conditions of the Statement:

- The proponent for the time being nominated by the Minister for Environment under section 38(6) of the *Environmental Protection Act 1986* is responsible for the implementation of the proposal unless and until that nomination has been revoked and another person is nominated.

- If the person nominated by the Minister, ceases to have responsibility for the proposal, that person is required to provide written notice to the Environmental Protection Authority of its intention to relinquish responsibility for the proposal and the name of the person to whom responsibility for the proposal will pass or has passed. The Minister for Environment may revoke a nomination made under section 38(6) of the *Environmental Protection Act 1986* and nominate another person.

- To initiate a change of proponent, the nominated proponent and proposed proponent are required to complete and submit Post Assessment Form 1 – Application to Change Nominated Proponent.

- The General Manager of the Office of the Environmental Protection Authority was the Chief Executive Officer of the Department of the Public Service of the State responsible for the administration of section 48 of the *Environmental Protection Act 1986* at the time the Statement was signed by the Minister for Environment.

**Appendix 3**
Proposed New Ministerial Statement

Statement No.

RECOMMENDED ENVIRONMENTAL CONDITIONS

**STATEMENT THAT A REVISED PROPOSAL MAY BE IMPLEMENTED (PURSUANT TO THE PROVISIONS OF THE *ENVIRONMENTAL PROTECTION ACT 1986*)**

West Angelas Iron Ore Project – Revised Proposal

**Proposal:** The development of iron ore mines at Deposits 'A', 'A west' 'B', 'E' and 'F' waste dumps, ore processing operation and associated infrastructure at West Angelas, 130 kilometres (km) west of Newman, and rail infrastructure, as documented in schedule 1 of this Ministerial Statement.

**Proponent:** Robe River Mining Company Pty. Ltd.

**Proponent Address:** 152-158 St Georges Terrace
PERTH WA 6000
GPO BoxA42, PERTH WA 6001

**Assessment Number:**

**Previous Assessment Number:** 1914

**Report of the Environmental Protection Authority:**

**Previous Report of the Environmental Protection Authority:** 1508

**Previous Ministerial Statement Number:** 970

The implementation of the proposal to which the above report of the Environmental Protection Authority relates is subject to the following conditions and procedures, which replace and supersede all previous conditions of Ministerial Statement 970.

## 1 Proposal Implementation

1-1 When implementing the proposal, the proponent shall not exceed the authorised extent of the proposal as defined in Column 3 of Table 2 in Schedule 1, unless amendments to the proposal and the authorised extent of the proposal have been approved under the *Environmental Protection Act 1986*.

## 2 Contact Details

2-1 The proponent shall notify the Chief Executive Officer (CEO) of the Office of the Environmental Protection Authority of any change of its name, physical address or postal address for the serving of notices or other correspondence within 28 days of such change. Where the proponent is a corporation or an association of persons, whether incorporated or not, the postal address is that of the principal place of business or of the principal office in the State.

## 3 Compliance Reporting

3-1 The proponent shall prepare and maintain a Compliance Assessment Plan to the satisfaction of the CEO.

3-2 The proponent shall submit to the CEO the Compliance Assessment Plan required by condition 3-1 prior to the first Compliance Assessment Report required by condition 3-6.

The compliance assessment plan shall indicate:

(1) the frequency of compliance reporting;

(2) the approach and timing of compliance assessment;

(3) the retention of compliance assessments;

(4) the method of reporting of potential non-compliance and corrective actions to take;

(5) the table of contents of Compliance Assessment reports; and

(6) public availability of Compliance Assessment Reports.

3-3 The proponent shall assess compliance with conditions in accordance with the Compliance Assessment Plan required by condition 3-1.

3-4 The proponent shall retain reports of all compliance assessments described in the Compliance Assessment Plan required by condition 3-1 and shall make those reports available when requested by the CEO.

3-5 The proponent shall advise the CEO of any potential non-compliance within seven days of that non-compliance being known.

3-6 The proponent shall submit to the CEO compliance assessment reports addressing compliance in the previous calendar year. Compliance Assessment Reports shall be submitted by the submission date defined in the Compliance Assessment Plan required by condition 3-1.

The compliance Assessment Report shall:

(1) be endorsed by the proponent's Managing Director/ General Manager/ Chief Executive Officer or a person delegated to sign on the Managing Director's/ General Manager's/ Chief Executive Officer's behalf;

(2) include a statement as to whether the proponent has complied with the conditions;

(3) identify all potential non-compliances and describe corrective and preventive actions taken;

(4) be made publicly available in accordance with the approved Compliance Assessment Plan; and

(5) indicate any proposed charges to the Compliance Assessment Plan required by condition 3-1.

## 4 Public Availability of Data

4-1 Subject to condition 4-2, within a reasonable time period, approved by the CEO, of the issue of this statement and for the remainder of the life of the proposal, the proponent shall make publicly available, in a manner approved by the CEO, all validated environmental data (including sampling design, sampling methodologies, empirical data and derived information products (e.g. maps)) relevant to the assessment of this proposal and implementation of this statement..

4-2 If any data referred to in condition 4-1 contains particulars of:

(1) a secret formula or process; or;

(2) confidential commercially sensitive information;

the proponent may submit a request for approval from the CEO to not make this data publicly available. In making such a request, the proponent shall provide the CEO with an explanation and reasons why the data should not be made publicly available.

## 5 Environmental Management Program

5-1 The proponent shall implement the proposal in accordance with the *"Environmental Management Program"*, dated September 2014, or subsequent revisions approved by the CEO.

The Environmental Management Program consists of the following Management Plans:

(1) Groundwater Management Plan;

(2) Surface Water Management Plan;

(3) Vegetation and Flora Management Plan;

(4) Fauna Management Plan;

(5) Dust Management Plan;

(6) Waste Management Plan; and

(7) Rail Management Plan.

Each Management Plan includes:

i. the specific environmental objectives and targets for each environmental factor;

ii. the management measures to be applied to avoid and minimise the environmental impact of the proposal;

iii. monitoring measures to measure the performance of management against targets; and

iv. contingency measures to mitigate impacts.

5-2 The proponent shall make the Environmental Management Program required by condition 5-1 publicly available, in a manner approved by the CEO.

## 6 Groundwater

6-1 The proponent shall manage groundwater abstraction and dewatering activities to ensure minimal adverse impacts on the availability and quality of groundwater resources and the dependent ecology.

6-2 To verify that the requirements of condition 6-1 are met the proponent shall undertake monitoring of groundwater levels and quality as outlined in the Groundwater Management Plan approved as part of Environmental Management Program, required by condition 5.

6-3 In the event that the monitoring required by condition 6-2 indicates that the requirements of condition 6-1 are not being met, the proponent shall implement contingency actions as outlined in the Groundwater Management Plan.

6-4 The proponent shall submit annually the results of monitoring required by condition 6-2 to the CEO as part of the Compliance Assessment Reports required by condition 3-6.

## 7 Surface Water

7-1 The proponent shall manage surface water drainage and discharge to ensure minimal adverse impacts on existing surface water drainage patterns or the water dependent ecosystems.

7-2 To verify that the requirements of condition 7-1 are met, the proponent shall undertake monitoring of the quality and quantity of water discharge and riparian vegetation health as outlined in the Surface Water Management Plan approved as part of the Environmental Management Program required by condition 5.

7-3 In the event that the monitoring required by condition 7-2 indicates that the requirements of condition 7-1 are not met, the proponent shall implement contingency actions as outlined in the Surface Water Management Plan.

7-4 The proponent shall submit annually the results of monitoring required by condition 7-2 to the CEO as part of the Compliance Assessment Reports required by condition 3-6.

## 8 Conservation Significant Communities and Species

8-1 The proponent shall manage clearing activities to ensure minimal adverse impacts on conservation significant communities and species.

8-2 To verify that the requirements of condition 8-1 are met, the proponent shall implement the proposal in accordance with the Vegetation and Flora Management Plan and Fauna Management Plan approved as part of the Environmental Management Program required by condition 5.

8-3 In the event that monitoring required by the Management Plans detailed in condition 8-2 indicates that the specific environmental objectives and targets, identified for each environmental factor, have been exceeded, the proponent shall:

(1) within 7 days of becoming aware of the exceedance, implement contingency measures as outlined in the management plans and continue implementation until environmental objectives and targets are being met, or as otherwise agreed by the CEO; and

(2) within 14 days of becoming aware of the exceedance, submit details of contingency measures implemented to the CEO.

## 9 Rehabilitation and closure

9-1 The proponent shall ensure that the mine is closed, decommissioned and rehabilitated in an ecologically sustainable manner, consistent with agreed post-mining outcomes and land uses, and without unacceptable liability to the State of Western Australia.

9-2 The proponent shall prepare a Mine Closure Plan for the West Angelas Iron Ore Project.

9-3 The Mine Closure Plan required by condition 9-2 shall:

(1) when implemented, manage the implementation of the proposal to meet the requirements of condition 9-1;

(2) be prepared in accordance with the *Guidelines for Preparing Mine Closure Plans, June 2011* (Department of Mines and Petroleum and Environmental Protection Authority) or its revisions; and

(3) be to the requirements of the CEO on advice of the Department of Mines and Petroleum.

9-4 The proponent shall review and revise the Mine Closure Plan required by Condition 9-2 at intervals not exceeding three years, or as otherwise specified by the CEO.

9-5 Revisions to the Mine Closure Plan may be approved by the CEO on the advice of the Department of Mines and Petroleum.

9-6 The proponent shall implement the latest revision of the Mine Closure Plan and continue implementation until otherwise agreed by the CEO.

## 10 Residual Impacts and Risk Management Measures

10-1 In view of the significant residual impacts and risks as a result of implementation of the Proposal, the proponent shall contribute funds to offset the clearing of native vegetation of 'good to excellent' condition in the Hamersley IBRA subregion, and calculated pursuant to condition 10-2. This funding shall be provided to a government-established conservation offset fund or an alternative offset arrangement providing an equivalent outcome as determined by the Minister.

10-2 The proponent's contribution to the conservation offset fund or alternative offset arrangement identified in condition 10-1 shall be paid biennially, the first payment due two years after the commencement of new ground disturbance approved under this Statement. The amount of funding will be $750 AUD (excluding GST) per hectare of 'good to excellent' condition native vegetation cleared within the development envelope (delineated in Figure 2 and defined by the geographic coordinates in Schedule 2) up to a maximum of 3,220 hectares (ha), within the Hamersley IBRA subregion.

10-3 The real value of contributions described in condition 10-2 will be maintained through indexation to the Perth Consumer Price Index (CPI), with the first adjustment to be applied to the first contribution.

10-4 The proponent shall prepare and submit an Impact Reconciliation Procedure to the satisfaction of the CEO.

10-5 The Impact Reconciliation Procedure required pursuant to condition 10-4 shall:

(1) include a methodology to identify clearing of 'good to excellent' condition native vegetation in the Hamersley IBRA subregion;

(2) require the proponent to submit spatial data identifying areas of 'good to excellent' condition native vegetation that has been cleared;

(3) include a methodology for calculating the amount of clearing undertaken during each biennial time period; and

(4) state dates for the commencement of the biennial time period and for the submission of results of the Impact Reconciliation Procedure, to the satisfaction of the CEO.

[Signed]

**HON ALBERT JACOB MLA**
**MINISTER FOR ENVIRONMENT; HERITAGE**

**Schedule 1**

**Table 1: Summary of the Revised Proposal**

| | |
|---|---|
| **Proposal title** | West Angelas Iron Ore Mine – Revised Proposal |
| **Proponent name** | Robe River Mining Co. Pty. Ltd. |
| **Short description** | Development and operation of an open-cut iron ore mine and associated infrastructure at the West Angelas Iron Ore Mine, 130 kilometres northwest of Newman in the Pilbara region (Figure 1). Iron ore is to be mined from above and below the water table in Deposits A, A west, B, E and F. The general layout of the mine and facilities are documented in Figure 2.<br><br>The mining operations are supplied with water from the mine dewatering bores and water from the Turee Creek B Borefield, located approximately 30 kilometres west of the mine site.<br><br>Surplus water, exceeding operational water demand is discharged to the environment.<br><br>Railway infrastructure from West Angelas to the port facilities at Cape Lambert (Figure 3). |

**Table 2: Location and authorised extent of physical and operational elements**

| Element | Location | Authorised Extent |
|---|---|---|
| Mining Area | Figure 2 | Clearing of no more than 3,180 hectares (ha) within a 22,600 ha development envelope. |
| Waste Dumps | Figure 2 | Clearing of no more than 3,260 ha within a 22,600 ha development envelope. |
| Associated infrastructure, access and accommodation | Figure 2 | Clearing of no more than 1,450 ha within a 22,600 ha development envelope. |
| Railway and associated infrastructure | Figure 3 | Not specified |

**Table 3: Abbreviations**

| Abbreviation | Term |
|---|---|
| CEO | The Chief Executive Officer of the Department of the Public Service of the State responsible for the administration of section 48 of the *Environmental Protection Act 1986*, or his delegate. |
| km | kilometre |
| ha | hectare |
| CPI | Consumer Price Index |

**Figures (attached)**

Figure 1 – Regional Location of West Angelas

Figure 2 – West Angelas Iron Ore Mine Indicative Layout and Approval Outline

Figure 3 – West Angelas Railway

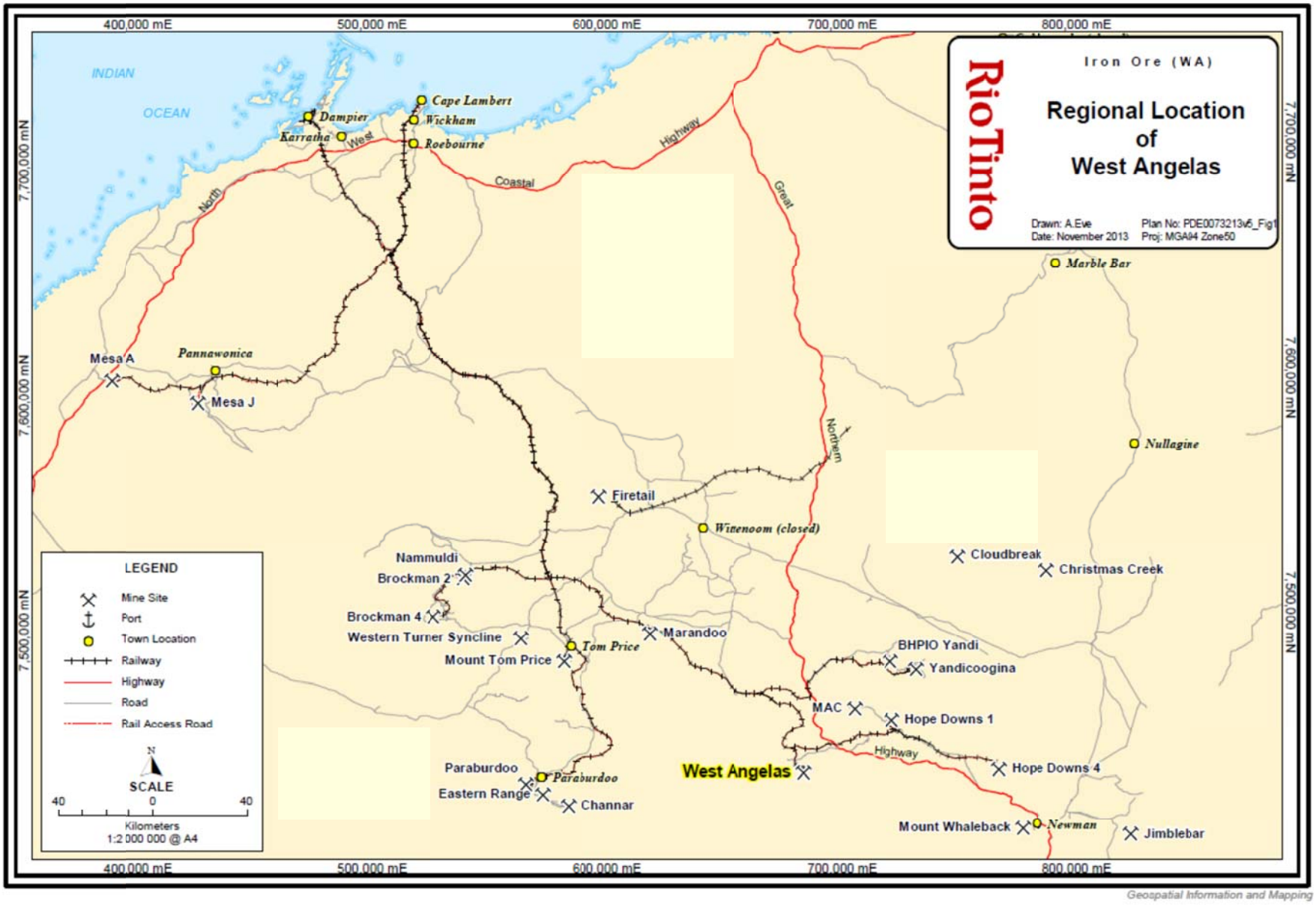



Figure 1: Regional Location of West Angelas

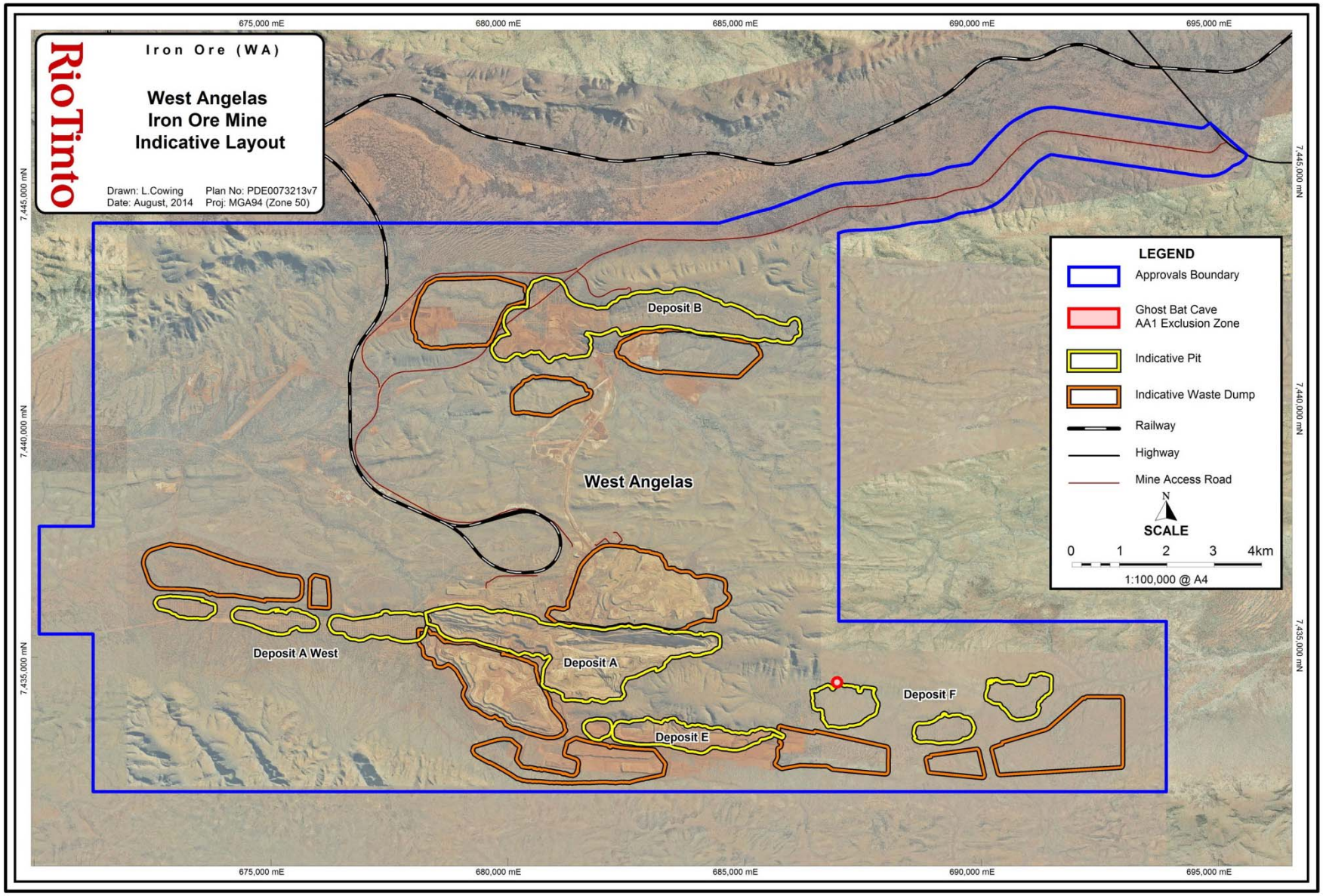



Figure 2: West Angelas Iron Ore Mine Indicative Layout

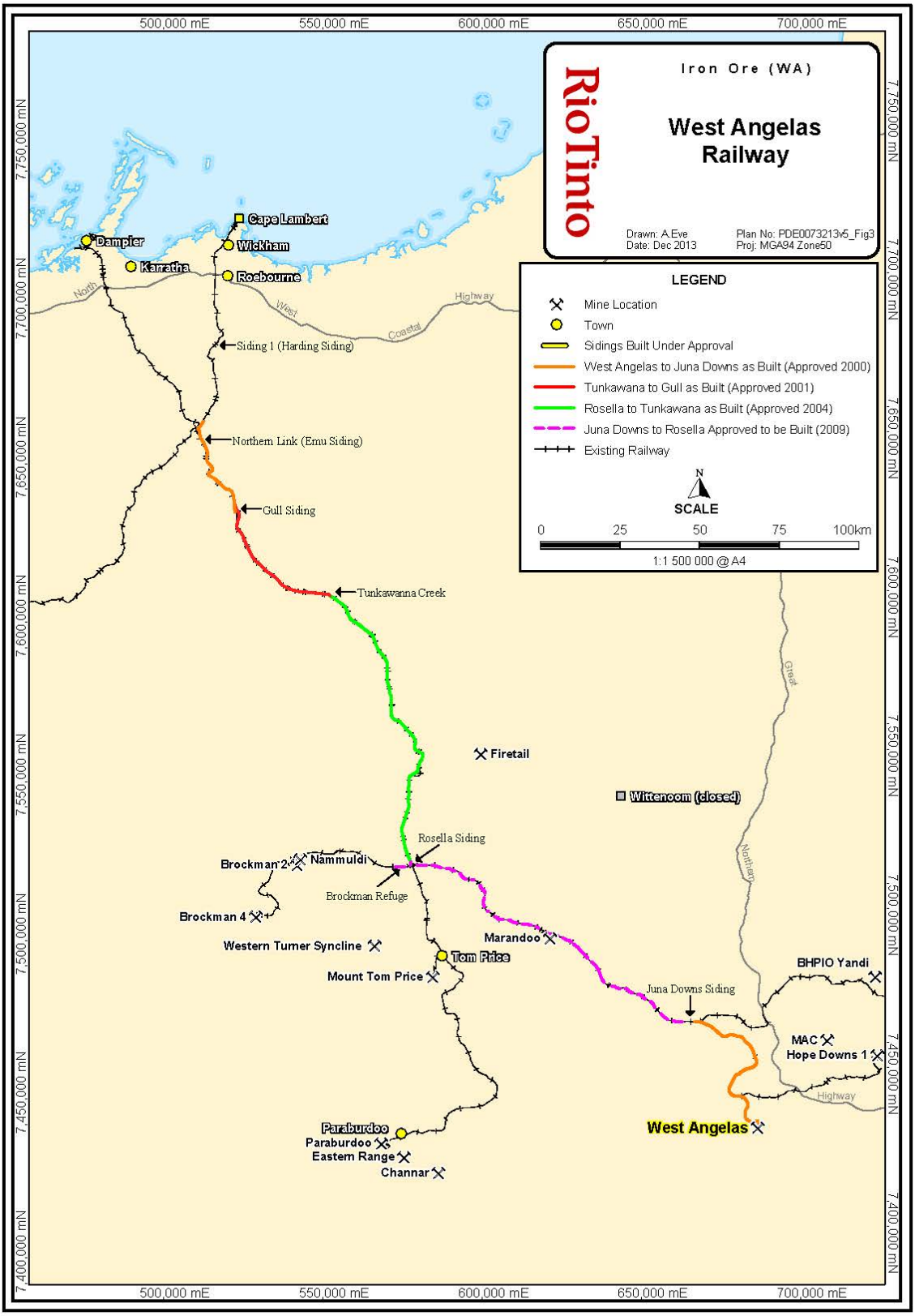



Figure 3: West Angelas Railway

**Schedule 2**

## West Angelas Iron Ore Project – Revised Proposal

Coordinates defining the development envelope are held by the Office of the Environmental Protection Authority, dated 30 September 2014

**Schedule 3**

## Notes

The following notes are provided for information and do not form a part of the implementation conditions of the Statement:

- The proponent for the time being nominated by the Minister for Environment under section 38(6) of the *Environmental Protection Act 1986* is responsible for the implementation of the proposal unless and until that nomination has been revoked and another person is nominated.

- If the person nominated by the Minister, ceases to have responsibility for the proposal, that person is required to provide written notice to the Environmental Protection Authority of its intention to relinquish responsibility for the proposal and the name of the person to whom responsibility for the proposal will pass or has passed. The Minister for Environment may revoke a nomination made under section 38(6) of the *Environmental Protection Act 1986* and nominate another person.

- To initiate a change of proponent, the nominated proponent and proposed proponent are required to complete and submit Post Assessment Form 1 – Application to Change Nominated Proponent.

- The General Manager of the Office of the Environmental Protection Authority was the Chief Executive Officer of the Department of the Public Service of the State responsible for the administration of section 48 of the *Environmental Protection Act 1986* at the time the Statement was signed by the Minister for Environment.

**Appendix 4**
Greater West Angelas
Vegetation and Flora
Assessment (*ecologia* 2013)

**Appendix 5**
Greater West Angelas
Terrestrial Fauna Assessment
(*ecologia* 2014)

**Appendix 6**

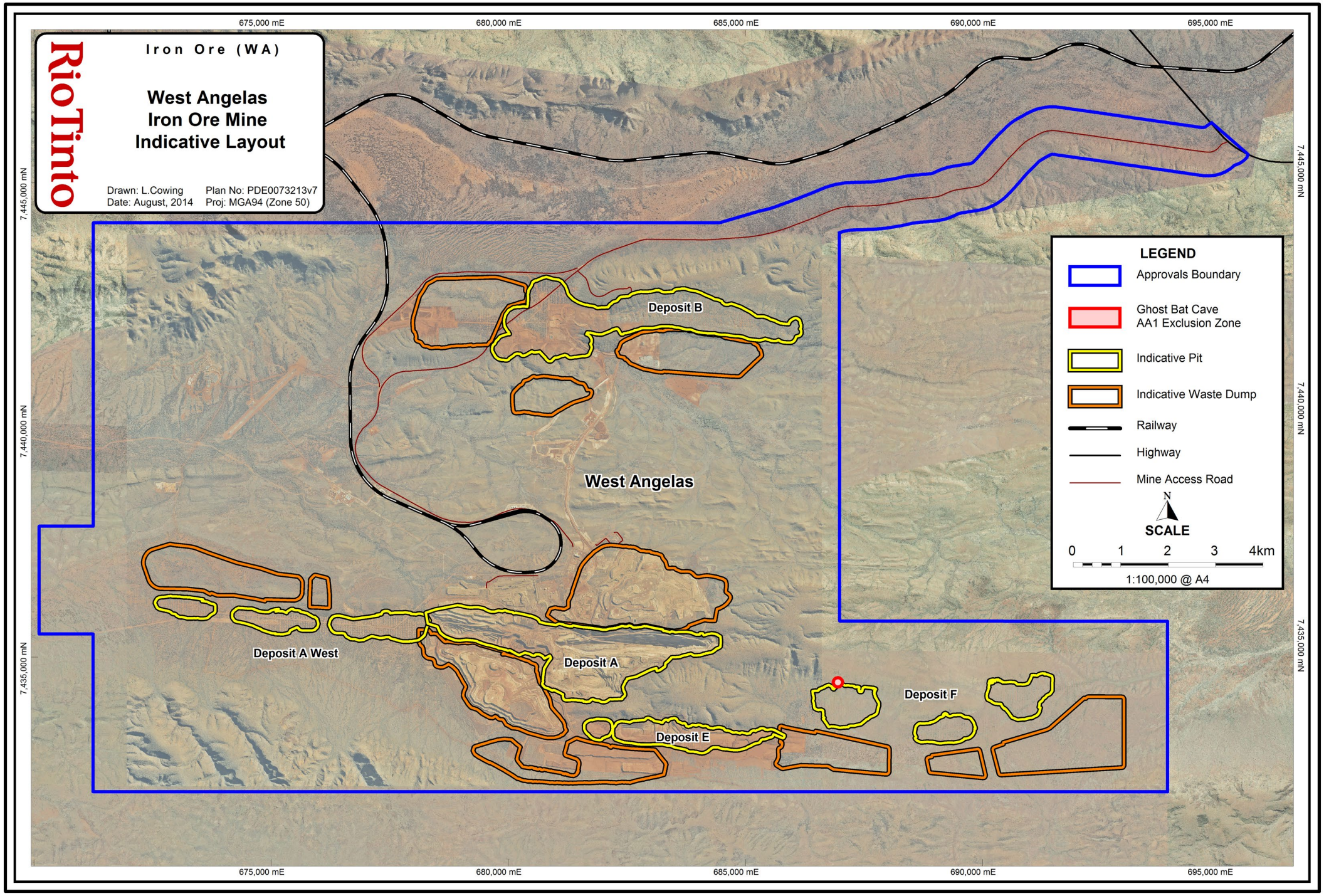
West Angelas Deposit B and F Ghost Bat Assessment (Biologic 2014)

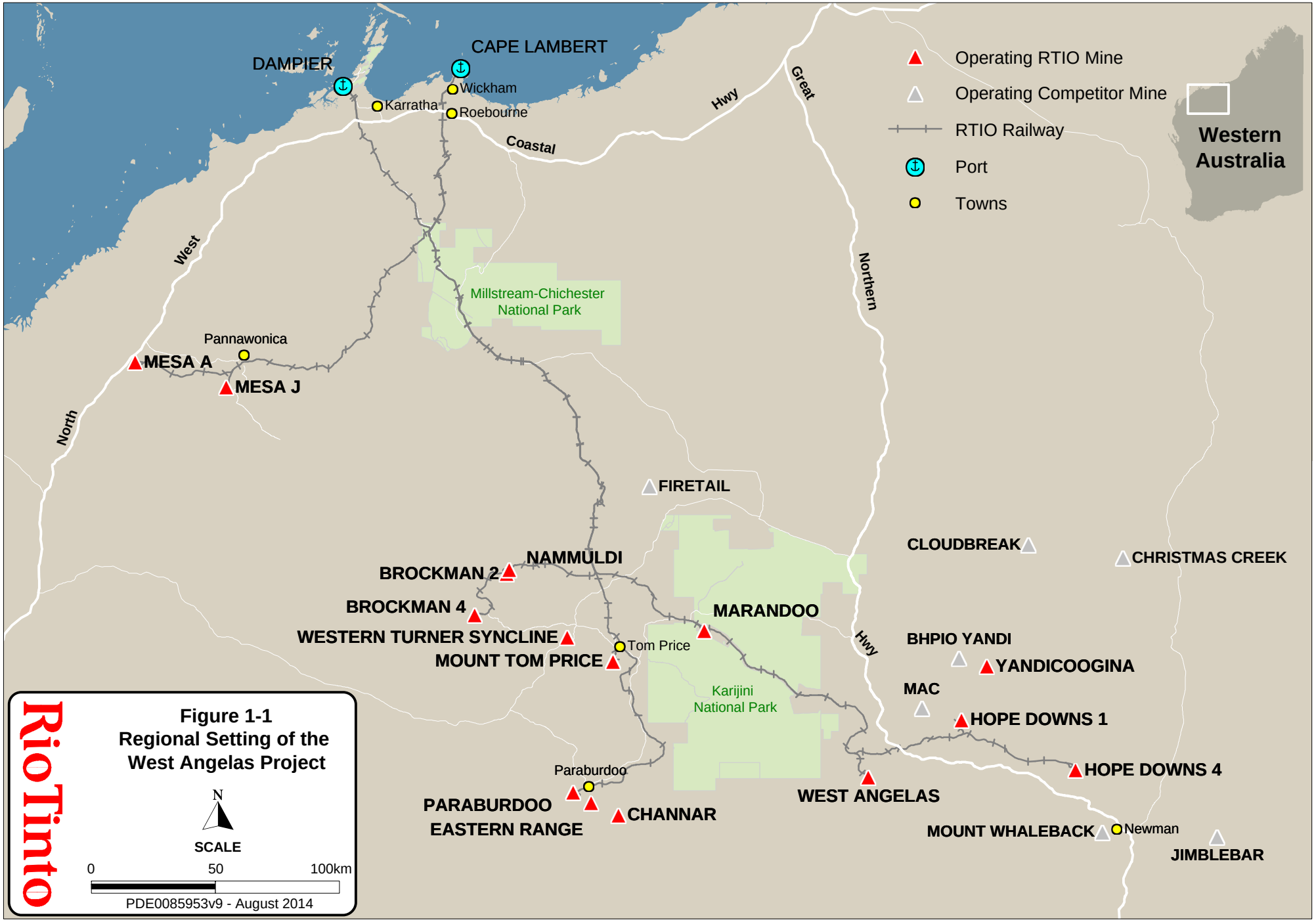
**Appendix 7**
West Angelas Operations
Environmental Management
Program 2014

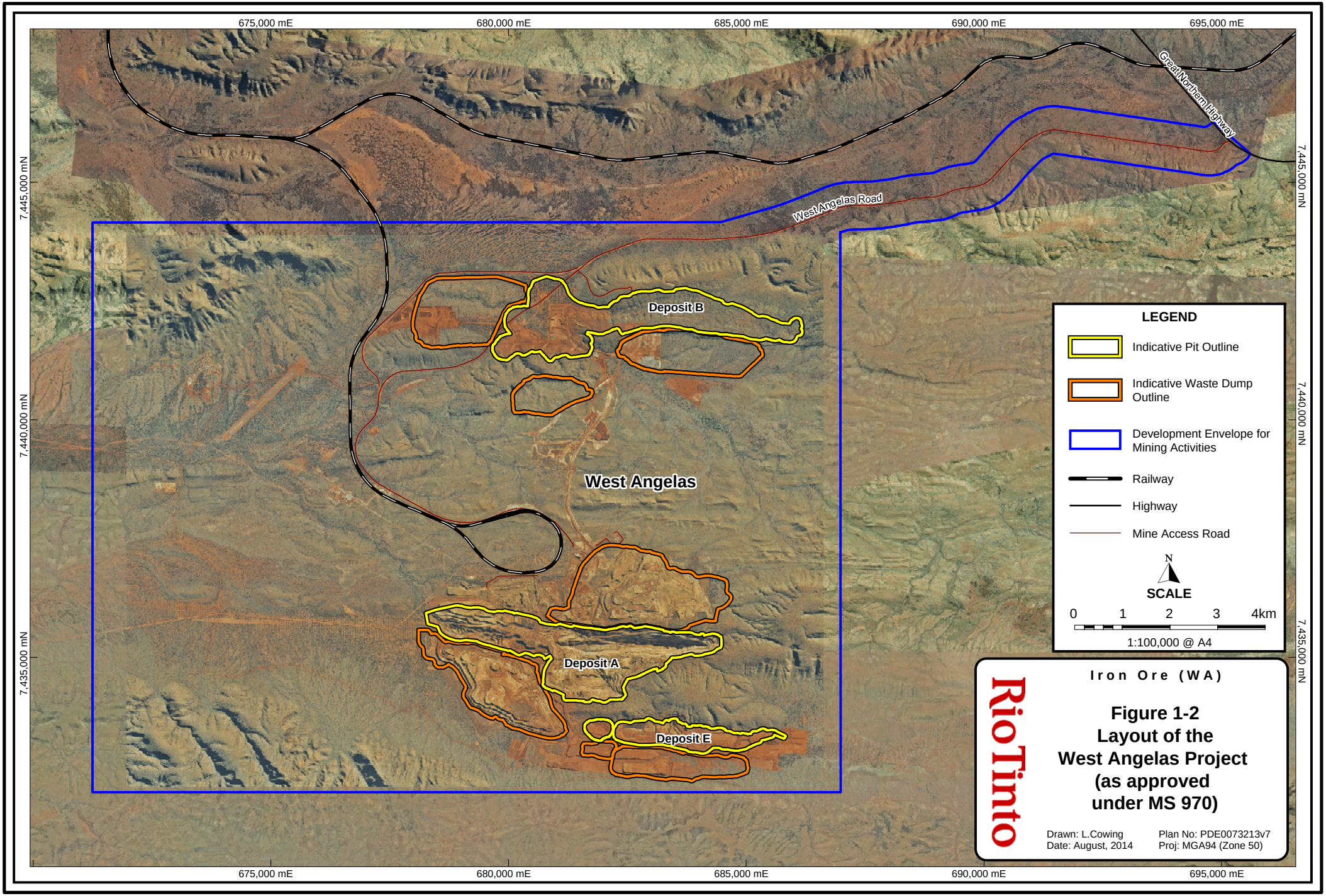
**Appendix 8**
West Angelas Closure Plan
2014

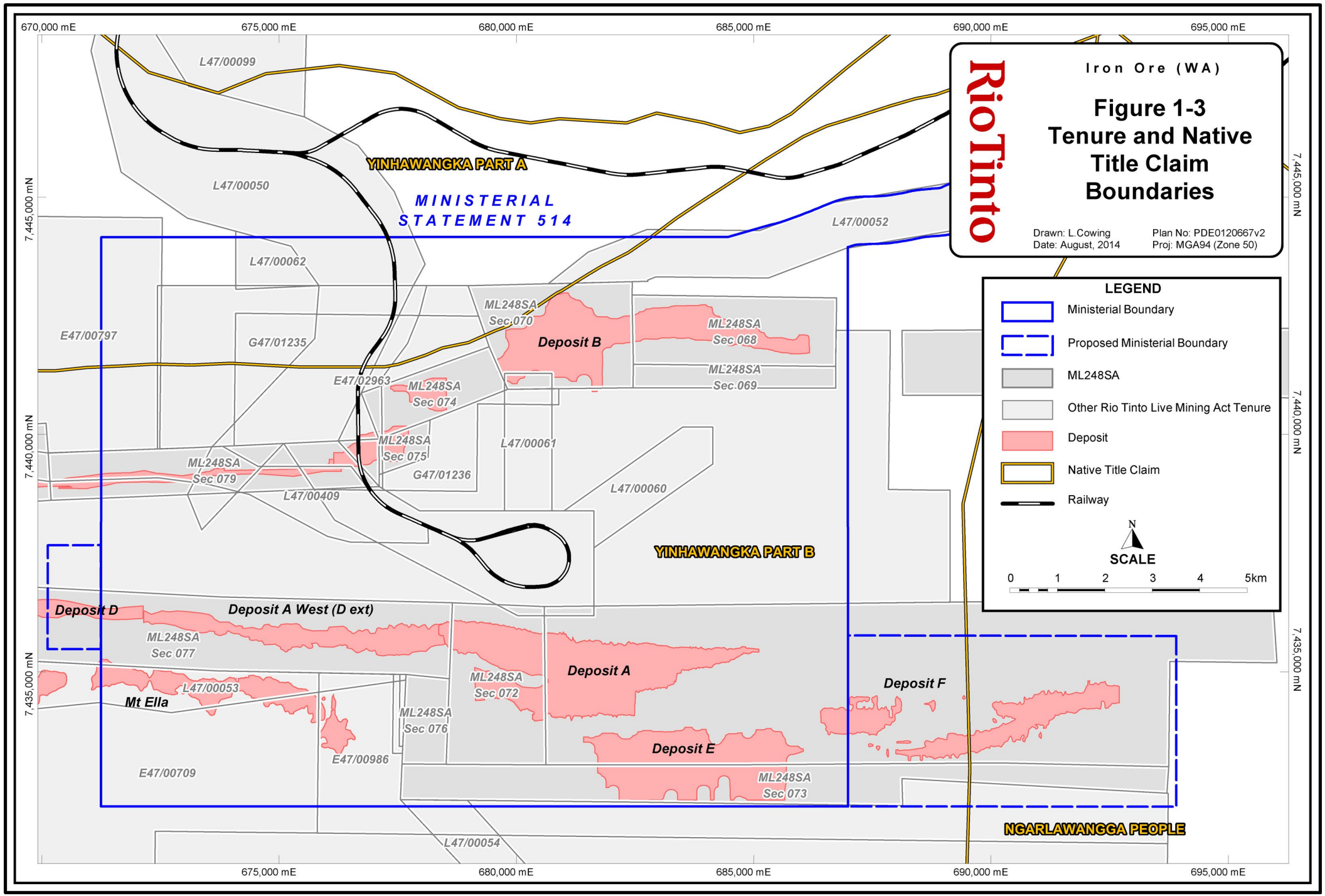
## Appendix 9

West Angelas Deposits A west and F Subterranean Fauna Assessment November 2014


Rio Tinto
Iron Ore (WA)
West Angelas
Iron Ore Mine
Indicative Layout
Drawn: L.Cowing
Date: August, 2014
Plan No: PDE0073213v7
Proj: MGA94 (Zone 50)
675,000 mE
680,000 mE
685,000 mE
690,000 mE
695,000 mE
7,445,000 mN
7,440,000 mN
7,435,000 mN
LEGEND
Approvals Boundary
Ghost Bat Cave
AA1 Exclusion Zone
Indicative Pit
Indicative Waste Dump
Railway
Highway
Mine Access Road
N
SCALE
0 1 2 3 4km
1:100,000 @ A4
Deposit B
West Angelas
Deposit A West
Deposit A
Deposit E
Deposit F


DAMPIER
CAPE LAMBERT
Wickham
Karratha
Roebourne
Coastal
Hwy
Great
Northern
West
North
Operating RTIO Mine
Operating Competitor Mine
RTIO Railway
Port
Towns
Western Australia
Millstream-Chichester National Park
Pannawonica
MESA A
MESA J
FIRETAIL
CLOUDBREAK
CHRISTMAS CREEK
NAMMULDI
BROCKMAN 2
BROCKMAN 4
MARANDOO
WESTERN TURNER SYNCLINE
Tom Price
MOUNT TOM PRICE
BHPIO YANDI
YANDICOOGINA
MAC
HOPE DOWNS 1
HOPE DOWNS 4
Karijini National Park
Paraburdoo
PARABURDOO
EASTERN RANGE
CHANNAR
WEST ANGELAS
MOUNT WHALEBACK
Newman
JIMBLEBAR
Rio Tinto
Figure 1-1
Regional Setting of the
West Angelas Project
N
SCALE
0
50
100km
PDE0085953v9 - August 2014


675,000 mE
680,000 mE
685,000 mE
690,000 mE
695,000 mE
7,445,000 mN
7,440,000 mN
7,435,000 mN
Great Northern Highway
West Angelas Road
Deposit B
West Angelas
Deposit A
Deposit E
LEGEND
Indicative Pit Outline
Indicative Waste Dump Outline
Development Envelope for Mining Activities
Railway
Highway
Mine Access Road
N
SCALE
0 1 2 3 4km
1:100,000 @ A4
Iron Ore (WA)
Figure 1-2
Layout of the
West Angelas Project
(as approved
under MS 970)
Drawn: L.Cowing
Date: August, 2014
Plan No: PDE0073213v7
Proj: MGA94 (Zone 50)


Iron Ore (WA)
Figure 1-3
Tenure and Native Title Claim Boundaries
Drawn: L.Cowing
Date: August, 2014
Plan No: PDE0120667v2
Proj: MGA94 (Zone 50)
LEGEND
Ministerial Boundary
Proposed Ministerial Boundary
ML248SA
Other Rio Tinto Live Mining Act Tenure
Deposit
Native Title Claim
Railway
N
SCALE
0 1 2 3 4 5km
670,000 mE
675,000 mE
680,000 mE
685,000 mE
690,000 mE
695,000 mE
7,445,000 mN
7,440,000 mN
7,435,000 mN
YINHAWANGKA PART A
MINISTERIAL STATEMENT 514
YINHAWANGKA PART B
NGARLAWANGGA PEOPLE
L47/00099
L47/00050
L47/00052
L47/00062
E47/00797
G47/01235
E47/02963
ML248SA Sec 070
ML248SA Sec 068
ML248SA Sec 069
ML248SA Sec 074
ML248SA Sec 075
ML248SA Sec 079
L47/00061
G47/01236
L47/00409
L47/00060
Deposit B
Deposit D
Deposit A West (D ext)
ML248SA Sec 077
Deposit A
ML248SA Sec 072
Deposit F
L47/00053
Mt Ella
ML248SA Sec 076
Deposit E
E47/00986
E47/00709
ML248SA Sec 073
L47/00054

Rio Tinto

Iron Ore (WA)

# Figure 2-1
# Proposed Layout of the Revised Proposal

Drawn: L.Cowing
Date: December, 2014

Plan No: PDE0073213v8
Proj: MGA94 (Zone 50)

670,000 mE
675,000 mE
680,000 mE
685,000 mE
690,000 mE

7,445,000 mN
7,440,000 mN
7,435,000 mN

Deposit B
West Angelas
Deposit A West
Deposit A
Deposit E
Deposit F

**LEGEND**

- Indicative Pit
- Proposed New Indicative Pit
- Indicative Waste Dump
- Proposed New Indicative Waste Dump
- Proposed Infrastructure
- Development Envelope for Mining Activities
- Evelopment Envelope Extension
- Railway
- Highway
- Mine Access Road

N

**SCALE**

0 1 2km

1:65,000 @ A3

670,000 mE
675,000 mE
680,000 mE
685,000 mE
690,000 mE

7,445,000 mN
7,440,000 mN
7,435,000 mN

**LEGEND**

- Indicative Pit
- Indicative Waste Dump
- Development Envelope for Mining Activities
- Development Envelope Extension
- Trudgen Vegetation Mapping, 1998
- Railway
- Highway
- Mine Access Road

N

**SCALE**

0 1 2km

1:65,000 @ A3

RioTinto

Iron Ore (WA)

# Figure 5-1
# Vegetation Mapping

Drawn: L.Cowing
Date: August, 2014

Plan No: PDE0073213v7
Proj: MGA94 (Zone 50)

Deposit B

West Angelas

Deposit A West

Deposit A

Deposit E

Deposit F

Rio Tinto

# Vegetation Mapping Legend

AaEffTp - Acacia aptaneura open woodland over Eremophila fraseri subsp. fraseri sparse shrubland over Triodia pungens sparse hummock grassland

AaPoEp - Acacia aptaneura open woodland over Ptilotus obovatus sparse shrubland over Enneapogon polyphyllus isolated tussock grasses

AaSaoTp - Acacia aptaneura open woodland over Senna artemisioides subsp. oligophylla sparse shrubland over Triodia pungens open hummock grassland

AaSggEp - Acacia aptaneura open woodland over Senna glutinosa subsp. glutinosa isolated shrubs over Enneapogon polyphyllus isolated tussock grasses

AaSlTp - Acacia aptaneura open woodland over Solanum lasiophyllum isolated shrubs over Triodia pungens open hummock grassland

AaAoAc - Acacia aptaneura sparse woodland over Abutilon otocarpum isolates shrubs over Aristida contorta sparse tussock grassland

AaEm - Acacia aptaneura sparse woodland over Eriachne mcronata sparse tussock grassland

AbPrIa - Acacia bivenosa isolated trees over Ptilotus rotundifolius isolated shrubs over Ischaemum albovillosum isolated tussock grasses

AiSggTw - Acacia inaequilatera isolated trees over Senna glutinosa subsp. glutinosa open shrubland over Triodia wiseana or Triodia pungens open hummock grassland

AmTw - Acacia maitlandii and/or Acacia bivenosa sparse woodland over Triodia wiseana hummock grassland

AmGtTssp - Acacia maitlandii open woodland over Goodenia triodiophilla isolated herbs and Triodia wiseana and/or T. basedowii and/or T. pungens open hummock grassland

ApTb - Acacia prionocarpa sparse woodland over Triodia basedowii and/or T. pungens open hummock grassland

ApSgg - Acacia pruinocarpa and/or A. maitlandii sparse woodland over Senna glutinosa subsp. glutinosa isolated shrubs

ApEcTp - Acacia pruinocarpa sparse woodland over Eremophila caespitosa sparse shrubland over Triodia pungens open hummock grassland

ChDllTt - Corymbia hamersleyana sparse woodland over Dodonaea lanceolata var. lanceolata isolated shrubs over Themeda triandra open tussock grassland

EgKvPm - Eucalyptus gamophylla sparse woodland over Keraudrenia velutina isolated shrubs over Paraneurachne muellerii isolated tussock grasses

EllEllTp - Eucalyptus leucophloia subsp. leucophloia sparse woodland over Eremophila latrobei subsp. latrobei isolated shrubs over Triodia pungens open hummock grassland

ExPnnTt - Eucalyptus xerothermica sparse woodland over Ptilotus nobilis subsp. nobilis sparse shrubland over Themeda triandra open tussock grassland

PsAjs - Pterocaulon sphacelatum sparse herbland and Aristida jerichoensis var. subspinulifera isolated tussock grasses

PnnAp - Ptilotus nobilis subsp. nobilis isolated shrubs over Astrebla pectinata open tussock grassland

SggIrTw - Senna glutinosa subsp. glutinosa open woodland over Indigofera rugosa sparse shrubland over Triodia wiseana hummock grassland

SggGrTp - Senna glutinosa subsp. glutinosa sparse woodland over Gossypium robinsonii sparse shrubland over Triodia pungens hummock grassland

670,000 mE 675,000 mE 680,000 mE 685,000 mE 690,000 mE

7,445,000 mN 7,440,000 mN 7,435,000 mN

**LEGEND**

- Indicative Pit Outline
- Dumps_2
- Development Envelope for Mining Activities
- Development Envelope Extension
- Railway
- Highway
- Mine Access Road

N

**SCALE**

0 1 2km

1:65,000 @ A3

Deposit B

West Angelas

Deposit A West

Deposit A

Deposit E

Deposit F

RioTinto

Iron Ore (WA)

# Figure 5-2 Flora of Conservation Significance

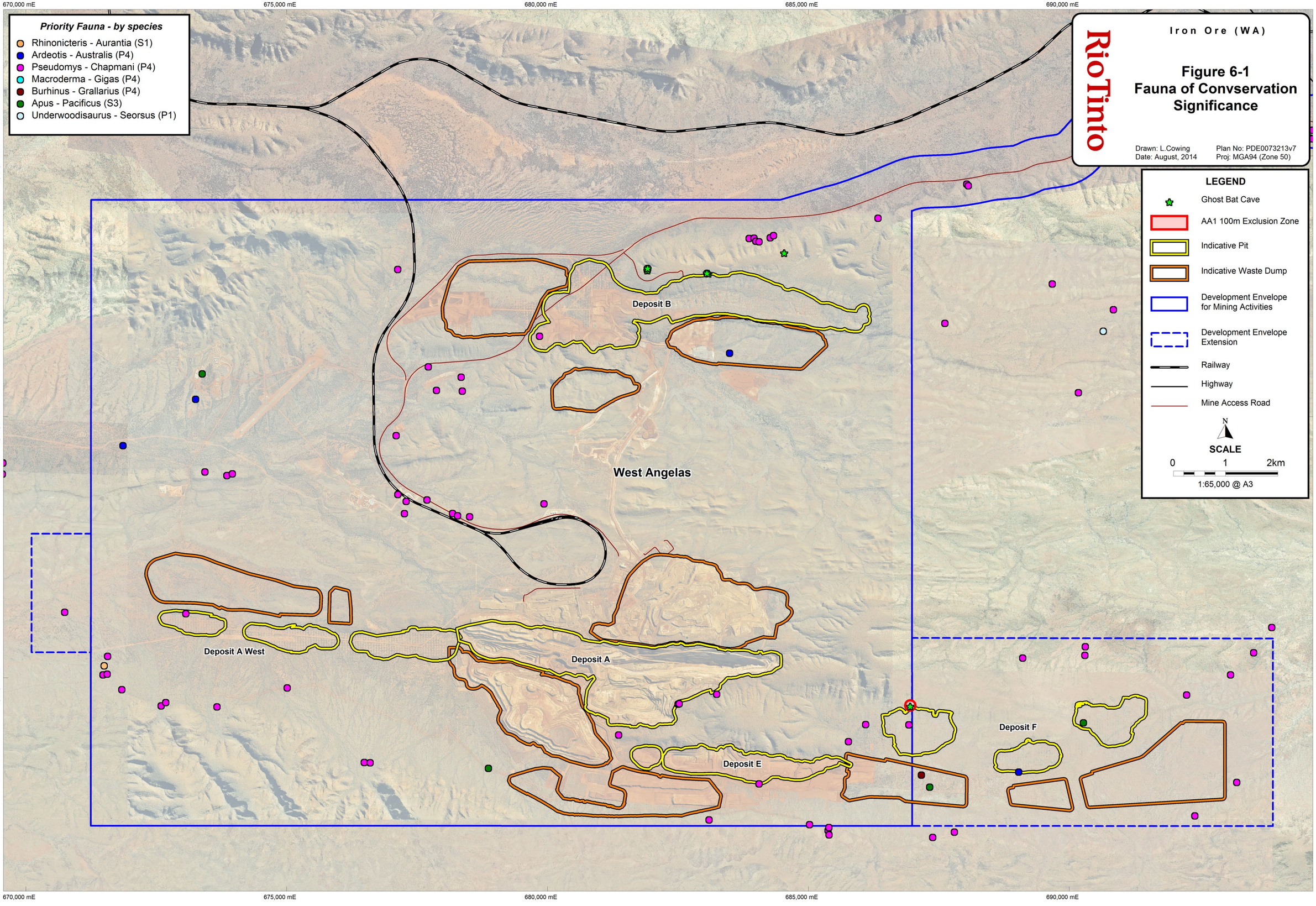
Drawn: L.Cowing
Date: August, 2014

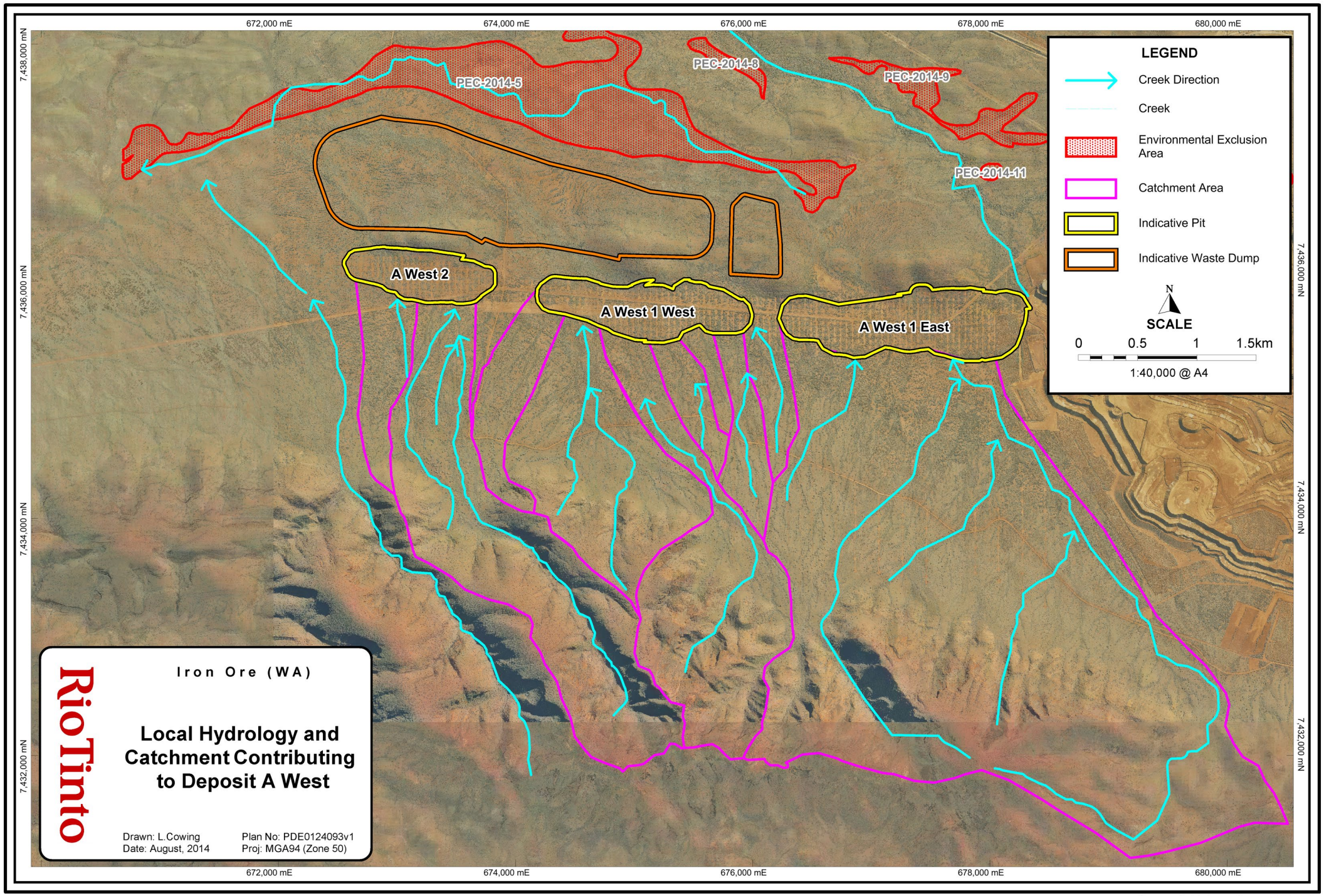
Plan No: PDE0073213v7
Proj: MGA94 (Zone 50)

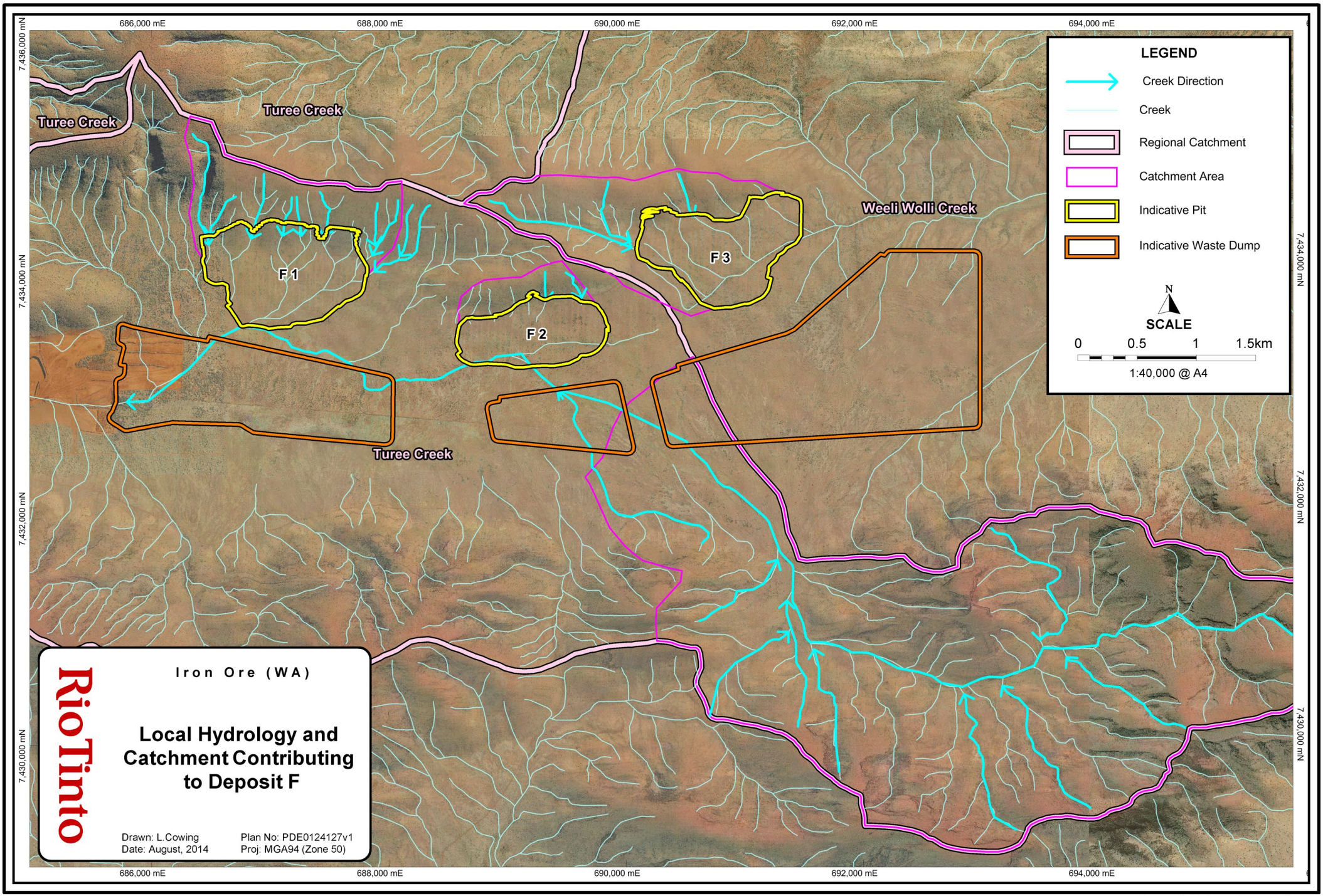
*Priority Flora - by Species*

- Aristida - ?Jerichoensis (P1)
- Tetratheca - Fordiana (P1)
- Aristida - Jerichoensis (P1)
- Brunonia - sp. Long hairs (D.E. Symon 2440) (P1)
- Josephinia - sp. Marandoo (M.E. Trudgen 1554) (P1)
- Euphorbia - Clementii (P2)
- Eremophila - Forrestii (P2)
- Aristida - Lazaridis (P2)
- Spartothamnella – Puberula (P2)
- Oxalis - sp. Pilbara (M.E. Trudgen 12725) (P2)
- Pilbara - Trudgenii (P2)
- Rostellularia - Adscendens (P3)
- Acacia - Effusa (P3)
- Solanum - Kentrocaule (P3)
- Sida - sp. Barlee Range (S. van Leeuwen 1642) (P3)
- Indigofera - sp. Gilesii (M. E. Trudgen 15869) (P3)
- Rhagodia - sp. Hamersley (M. Trudgen 17794) (P3)
- Themeda - sp. Hamersley Station (M.E. Trudgen 11431) (P3)
- Triodia - sp. Mt Ella (M.E. Trudgen 12739) (P3)
- Brachyscome - sp. Wanna Munna Flats (S. van Leeuwen 4662) (P3)
- Acacia - Subtiliformis (P3)
- Goodenia - ?Nuda (P4)
- Acacia - Bromilowiana (P4)
- Olearia - Mucronata (P4)
- Goodenia - Nuda (P4)
- Lepidium - Catapycnon (R)

670,000 mE 675,000 mE 680,000 mE 685,000 mE 690,000 mE


Priority Fauna - by species
Rhinonicteris - Aurantia (S1)
Ardeotis - Australis (P4)
Pseudomys - Chapmani (P4)
Macroderma - Gigas (P4)
Burhinus - Grallarius (P4)
Apus - Pacificus (S3)
Underwoodisaurus - Seorsus (P1)
670,000 mE
675,000 mE
680,000 mE
685,000 mE
690,000 mE
7,445,000 mN
7,440,000 mN
7,435,000 mN
Deposit B
West Angelas
Deposit A West
Deposit A
Deposit E
Deposit F
RioTinto
Iron Ore (WA)
Figure 6-1
Fauna of Convservation Significance
Drawn: L.Cowing
Date: August, 2014
Plan No: PDE0073213v7
Proj: MGA94 (Zone 50)
LEGEND
Ghost Bat Cave
AA1 100m Exclusion Zone
Indicative Pit
Indicative Waste Dump
Development Envelope for Mining Activities
Development Envelope Extension
Railway
Highway
Mine Access Road
N
SCALE
0
1
2km
1:65,000 @ A3


672,000 mE
674,000 mE
676,000 mE
678,000 mE
680,000 mE
7,438,000 mN
7,436,000 mN
7,434,000 mN
7,432,000 mN
PEC-2014-5
PEC-2014-8
PEC-2014-9
PEC-2014-11
A West 2
A West 1 West
A West 1 East
LEGEND
Creek Direction
Creek
Environmental Exclusion Area
Catchment Area
Indicative Pit
Indicative Waste Dump
N
SCALE
0
0.5
1
1.5km
1:40,000 @ A4
Iron Ore (WA)
Local Hydrology and Catchment Contributing to Deposit A West
Drawn: L.Cowing
Date: August, 2014
Plan No: PDE0124093v1
Proj: MGA94 (Zone 50)
Geospatial Information and Mapping


686,000 mE
688,000 mE
690,000 mE
692,000 mE
694,000 mE
7,436,000 mN
7,434,000 mN
7,432,000 mN
7,430,000 mN
Turee Creek
Turee Creek
Turee Creek
Weeli Wolli Creek
F 1
F 2
F 3
LEGEND
Creek Direction
Creek
Regional Catchment
Catchment Area
Indicative Pit
Indicative Waste Dump
N
SCALE
0
0.5
1
1.5km
1:40,000 @ A4
Iron Ore (WA)
Local Hydrology and Catchment Contributing to Deposit F
Drawn: L.Cowing
Date: August, 2014
Plan No: PDE0124127v1
Proj: MGA94 (Zone 50)
Geospatial Information and Mapping

Environmental Protection Authority

GOVERNMENT OF WESTERN AUSTRALIA

EPA REFERRAL FORM PROPONENT

# Referral of a Proposal by the Proponent to the Environmental Protection Authority under Section 38(1) of the *Environmental Protection Act 1986*.

## PURPOSE OF THIS FORM

Section 38(1) of the *Environmental Protection Act 1986* (EP Act) provides that where a development proposal is likely to have a significant effect on the environment, a proponent may refer the proposal to the Environmental Protection Authority (EPA) for a decision on whether or not it requires assessment under the EP Act. This form sets out the information requirements for the referral of a proposal by a proponent.

Proponents are encouraged to familiarise themselves with the EPA's *General Guide on Referral of Proposals* [see Environmental Impact Assessment/Referral of Proposals and Schemes] before completing this form.

A referral under section 38(1) of the EP Act by a proponent to the EPA must be made on this form. A request to the EPA for a declaration under section 39B (derived proposal) must be made on this form. This form will be treated as a referral provided all information required by Part A has been included and all information requested by Part B has been provided to the extent that it is pertinent to the proposal being referred. Referral documents are to be submitted in two formats – hard copy and electronic copy. The electronic copy of the referral will be provided for public comment for a period of 7 days, prior to the EPA making its decision on whether or not to assess the proposal.

## CHECKLIST

Before you submit this form, please check that you have:

| | Yes | No |
|---|---|---|
| Completed all the questions in Part A (essential). | ✓ | |
| Completed all applicable questions in Part B. | ✓ | |
| Included Attachment 1 – location maps. | ✓ | |
| Included Attachment 2 – additional document(s) the proponent wishes to provide (if applicable). | ✓ | |
| Included Attachment 3 – confidential information (if applicable). | | |
| Enclosed an electronic copy of all referral information, including spatial data and contextual mapping but excluding confidential information. | ✓ | |

Following a review of the information presented in this form, please consider the following question (a response is optional).

| Do you consider the proposal requires formal environmental impact assessment? | | |
|---|---|---|
| ☒ Yes | ☐ No | ☐ Not sure |
| If yes, what level of assessment? | | |
| ☒ Assessment on Proponent Information | ☐ Public Environmental Review | |

**PROPONENT DECLARATION** (to be completed by the proponent)

I, Clayton Walker, declare that I am authorised on behalf of Robe River Mining Co. Pty. Ltd to submit this form and further declare that the information contained in this form is true and not misleading.

| | |
|---|---|
| Signature:  | Name (print): Clayton Walker |
| Position: Director | Company: Robe River Mining Co. Pty. Ltd. |
| Date: 5 December 2014 | |

## PART A - PROPONENT AND PROPOSAL INFORMATION

(All fields of Part A must be completed for this document to be treated as a referral)

## 1 PROPONENT AND PROPOSAL INFORMATION

### 1.1 Proponent

| | |
|---|---|
| Name | Robe River Mining Co. Pty. Ltd. |
| Joint Venture parties (if applicable) | Robe River Joint Venture Participants |
| Australian Company Number (if applicable) | 71 008 694 246 |
| Postal Address<br>(where the proponent is a corporation or an association of persons, whether incorporated or not, the postal address is that of the principal place of business or of the principal office in the State) | GPO Box A42<br>Perth WA 6837 |
| Key proponent contact for the proposal:<br>• name<br>• address<br>• phone<br>• email | Carly Nixon<br>Environmental Approvals Specialist<br>GPO Box A42<br>Perth WA 6837<br>T: +61 (08) 6213 1297<br>carly.nixon@riotinto.com |
| Consultant for the proposal (if applicable):<br>• name<br>• address<br>• phone<br>• email | NA |

### 1.2 Proposal

| | |
|---|---|
| Title | West Angelas Deposit A west and Deposit F Revised Proposal. |
| Description | The Proponent, Robe River Mining Co. Pty. Ltd., on behalf of the Robe River Joint Venture Participants, proposes to mine iron ore from above and below the water table at Deposits A west and F, as satellite deposits to the existing West Angelas mining operations. Once mined, ore will be transported by haul trucks to existing processing facilities. |
| Extent (area) of proposed ground disturbance. | The Proposal will require clearing of approximately 3,220 ha.<br><br>This referral is not seeking approval for activities already authorised as part of the existing operations. |

| | |
|---|---|
| Timeframe in which the activity or development is proposed to occur (including start and finish dates where applicable). | Production commenced at the existing West Angelas mining operations in 2001 at Deposit A and in 2011 at Deposit E. Deposit A provides the primary ore source with Deposit E supplementing the production to maintain the current production rate. Deposit B is the next major ore source with mining scheduled to commence in 2015. Production from all existing deposits will decline from 2016. An additional ore source is therefore required to sustain current production from the West Angelas Project. Deposits A west and F have been identified as the next to be developed in the conceptual long term development strategy.<br><br>Robe proposes to commence mining of Deposits A west and F in 2016. |
| Details of any staging of the proposal. | The Proposal is not staged. |
| Is the proposal a strategic proposal? | No. |
| Is the proponent requesting a declaration that the proposal is a derived proposal? | No. |
| Please indicate whether, and in what way, the proposal is related to other proposals in the region. | Deposits A west and F will be developed as satellite deposits to the existing West Angelas mining operations. |
| Does the proponent own the land on which the proposal is to be established? If not, what other arrangements have been established to access the land? | The West Angelas Iron Ore Mine is located on Mineral Lease 248SA (AML248SA) which was granted in 1976 under the *Iron Ore (Robe River) Agreement Act 1964*. The infrastructure associated with the West Angelas mining operations is located on a number of Miscellaneous Licences and General Purpose Leases that were granted under the *Mining Act 1978*. The Leases are held under the Robe River Joint Venture which is managed on behalf of the partners by Robe River Mining Co. Pty. Ltd.<br><br>The current tenure is appropriate tenure for all current and proposed mining activities and mining related infrastructure. |
| What is the current land use on the property, and the extent (area in hectares) of the property? | The location of West Angelas is very remote, with no neighbouring mining or pastoral activities. |

## 1.3 Location

| | |
|---|---|
| Name of the Shire in which the proposal is located. | The Proposal is located in the Shire of East Pilbara. |
| For urban areas:<br>• street address;<br>• lot number;<br>• suburb; and<br>• nearest road intersection. | NA. |
| For remote localities:<br>• nearest town; and<br>• distance and direction from that town to the proposal site. | The West Angelas Iron Ore Mine is located approximately 130 kilometres (km) northwest of Newman in the Pilbara region of Western Australia. |
| Electronic copy of spatial data - GIS or CAD, geo-referenced and conforming to the following parameters:<br>• GIS: polygons representing all activities and named;<br>• CAD: simple closed polygons representing all activities and named;<br>• datum: GDA94;<br>• projection: Geographic (latitude/longitude) or Map Grid of Australia (MGA);<br>• format: Arcview shapefile, Arcinfo coverages, Microstation or AutoCAD. | Enclosed?: **Yes.** |

## 1.4 Confidential Information

| | |
|---|---|
| Does the proponent wish to request the EPA to allow any part of the referral information to be treated as confidential? | No. |
| If yes, is confidential information attached as a separate document in hard copy? | NA. |

## 1.5 Government Approvals

| | | | |
|---|---|---|---|
| Is rezoning of any land required before the proposal can be implemented?<br>If yes, please provide details. | | No. | |
| Is approval required from any Commonwealth or State Government agency or Local Authority for any part of the proposal?<br>If yes, please complete the table below. | | Yes. | |
| Agency/Authority | Approval required | Application lodged Yes / No | Agency/Local Authority contact(s) for proposal |

| | | | |
|---|---|---|---|
| Minister for Environment; Environmental Protection Authority<br>(EPA) | *Environmental Protection Act 1986* (WA) - Part IV: Ministerial Statement | Purpose of this document | EPA<br>The Atrium<br>168 St Georges Tce<br>PERTH WA 6000 |
| Department of Water<br>(DoW) | *Rights in Water and Irrigation Act 1914 (WA):* Licenses to Construct Wells and Take Water | No | DoW<br>The Atrium<br>168 St Georges Tce<br>PERTH WA 6000 |

## PART B - ENVIRONMENTAL IMPACTS AND PROPOSED MANAGEMENT

### 2. ENVIRONMENTAL IMPACTS

Describe the impacts of the proposal on the following elements of the environment, by answering the questions contained in Sections 2.1-2.11:

2.1 flora and vegetation;

2.2 fauna;

2.3 rivers, creeks, wetlands and estuaries;

2.4 significant areas and/ or land features;

2.5 coastal zone areas;

2.6 marine areas and biota;

2.7 water supply and drainage catchments;

2.8 pollution;

2.9 greenhouse gas emissions;

2.10 contamination; and

2.11 social surroundings.

These features should be shown on the site plan, where appropriate.

For all information, please indicate:

(a) the source of the information; and

(b) the currency of the information.

### 2.1 Flora and Vegetation

2.1.1 Do you propose to clear any native flora and vegetation as a part of this proposal?

[A proposal to clear native vegetation may require a clearing permit under Part V of the EP Act (Environmental Protection (Clearing of Native Vegetation) Regulations 2004)]. Please contact the Department of Environment and Conservation (DEC) for more information.

(please tick) ☒ Yes **If yes**, complete the rest of this section.

☐ No **If no**, go to the next section

2.1.2 How much vegetation are you proposing to clear (in hectares)?

The Proposal will require clearing of approximately 3,220 hectares (ha).

This proposed clearing is comprised of the following components: clearing for mining will be increased by 920 ha, from 2,260 ha to 3,180 ha; clearing for waste dumps will be increased by approximately 1,853 ha, from 1,407 ha to 3,260 ha; and clearing for infrastructure will be increased by 450 ha, from 1,000 ha to 1,450 ha.

2.1.3 Have you submitted an application to clear native vegetation to the DEC (unless you are exempt from such a requirement)?

☐ Yes ☒ No **If yes**, on what date and to which office was the application submitted of the DEC?

The clearing required for this Proposal is the subject of this application.

2.1.4 Are you aware of any recent flora surveys carried out over the area to be disturbed by this proposal?

☒ Yes ☐ No **If yes**, please attach a copy of any related survey reports and provide the date and name of persons / companies involved in the survey(s).

**If no**, please do not arrange to have any biological surveys conducted prior to consulting with the DEC.

Refer to Section 5 of the Environmental Review Document.

2.1.5 Has a search of DEC records for known occurrences of rare or priority flora or threatened ecological communities been conducted for the site?

☒ Yes ☐ No If you are proposing to clear native vegetation for any part of your proposal, a search of DEC records of known occurrences of rare or priority flora and threatened ecological communities will be required. Please contact DEC for more information.

A search of Department of Parks and Wildlife (DPaW) records was undertaken as part of the vegetation and flora assessment undertaken by *ecologia*.

2.1.6 Are there any known occurrences of rare or priority flora or threatened ecological communities on the site?

☒ Yes ☐ No **If yes**, please indicate which species or communities are involved and provide copies of any correspondence with DEC regarding these matters.

The Priority 1; West Angelas Cracking-Clay Priority Ecological Community (**PEC**) occurs extensively within the area. This community is defined as 'open tussock grasslands of *Astrebla pectinata*, *A. elymoides*, *Aristida latifolia* in combination with *Astrebla squarrosa* and low scattered shrubs of *Sida fibulifera*, on basalt derived cracking-clay loam depressions and flowlines'. Threats to this community include; clearing for further mining expansion and future infrastructure development, weed invasion and changes in fire regimes.

The West Angelas Cracking Clay PEC is not proposed to be detrimentally impacted by the Proposal.

Nine Priority Flora records are considered to be of relevance to the Proposal:

- *Aristida jerichoensis* var. *subspinulifera* (Priority (**P**) 1);
- *Brachyscome* sp. Wanna Munna Flats (S. van Leeuwen 4662) (P1);
- *Brunonia* sp. long hairs (D.E. Symon 2440) (P1);
- *Aristida lazaridis* (P2);
- *Indigofera gilesii* subsp. *gilesii* (P3);
- *Themeda* sp. Hamersley Station (M.E. Trudgen 11431) (P3);
- *Triodia* sp. Mt Ella (M.E. Trudgen 12739) (P3);
- *Rhagodia* sp. Hamersley (M. Trudgen 17794) (P3); and
- *Goodenia nuda* (P4).

Refer to Section 5 of the Environmental Review Document.

2.1.7 If located within the Perth Metropolitan Region, is the proposed development within or adjacent to a listed Bush Forever Site? (You will need to contact the Bush Forever Office, at the Department for Planning and Infrastructure)

☐ Yes ☐ No **If yes**, please indicate which Bush Forever Site is affected (site number and name of site where appropriate).

Not applicable.

2.1.8 What is the condition of the vegetation at the site?

West Angelas is not located within a pastoral lease and, as a result, is not actively grazed. Subsequently, the vegetation condition was assessed to be in very good to excellent condition despite evidence of weed invasion.

Refer to Section 5 of the Environmental Review Document.

## 2.2 Fauna

2.2.1 Do you expect that any fauna or fauna habitat will be impacted by the proposal?

(please tick) ☒ Yes **If yes**, complete the rest of this section.

☐ No **If no**, go to the next section.

2.2.2 Describe the nature and extent of the expected impact.

The Proposal will result in the clearing of up to 3,220 ha of potential fauna habitat, therefore habitat loss is likely to be the biggest threat to fauna, including several conservation significant fauna species (namely: Fork-tailed Swift, the Western Pebble-mound Mouse, the Short-tailed Mouse, the Ghost Bat, the Bush Stone-curlew and the Australian Bustard).

2.2.3 Are you aware of any recent fauna surveys carried out over the area to be disturbed by this proposal?

☒ Yes ☐ No **If yes**, please attach a copy of any related survey reports and provide the date and name of persons / companies involved in the survey(s).

**If no**, please do not arrange to have any biological surveys conducted prior to consulting with the DEC.

Refer to Section 6 of the Environmental Review Document.

2.2.4 Has a search of DEC records for known occurrences of Specially Protected (threatened) fauna been conducted for the site?

☒ Yes ☐ No (please tick)

A search of DPaW records was undertaken as part of the terrestrial fauna assessment undertaken by *ecologia*.

2.2.5 Are there any known occurrences of Specially Protected (threatened) fauna on the site?

☒ Yes ☐ No **If yes**, please indicate which species or communities are involved and provide copies of any correspondence with DEC regarding these matters.

Six conservation significant species recorded or assessed as having a high likelihood of occurrence are considered to be of relevance to the Proposal:

- Fork-tailed Swift, *Apus pacificus* (EPBC M, WC Act S3);
- Western Pebble-mound Mouse, *Pseudomys chapmani* (DPaW P4);
- Short-tailed Mouse, *Leggadina lakedownensis* (DPaW P4);
- Ghost Bat, *Macroderma gigas* (DPaW P4);
- Bush Stone-curlew, *Burhinus grallarius* (DPaW P4); and
- Australian Bustard, *Ardeotis australis* (DPaW P4).

The presence of the Ghost Bat represents the most significant faunal finding. Populations of this species are known from a series of roost caves in the region including the potential maternity cave; AA1 near Deposit F.

Refer to Section 6 of the Environmental Review Document.

### 2.3 Rivers, Creeks, Wetlands and Estuaries

2.3.1 Will the development occur within 200 metres of a river, creek, wetland or estuary?

(please tick) ☒ Yes **If yes**, complete the rest of this section.

☐ No **If no**, go to the next section.

2.3.2 Will the development result in the clearing of vegetation within the 200 metre zone?

☐ Yes ☒ No **If yes**, please describe the extent of the expected impact.

2.3.3 Will the development result in the filling or excavation of a river, creek, wetland or estuary?

☒ Yes ☐ No **If yes**, please describe the extent of the expected impact.

Deposit F is located within the same valley as an ephemeral unnamed tributary, hereafter referred to as central creek.

Central creek will be intercepted immediately upstream of Deposit F.

2.3.4 Will the development result in the impoundment of a river, creek, wetland or estuary?

☒ Yes ☐ No **If yes**, please describe the extent of the expected impact.

Deposit F, Pit F2 naturally intercepts central creek. A 2% AEP capacity diversion channel is proposed to divert the creek upstream of the F2 pit eastwards across the catchment divide into the adjacent Weeli Wolli catchment. No viable alternative option exists to continue the flow of this creek within its natural catchment.

Refer to Section 7 of the Environmental Review Document.

2.3.5 Will the development result in draining to a river, creek, wetland or estuary?

☐ Yes ☒ No **If yes**, please describe the extent of the expected impact.

2.3.6 Are you aware if the proposal will impact on a river, creek, wetland or estuary (or its buffer) within one of the following categories? (please tick)

| | | | |
|---|---|---|---|
| Conservation Category Wetland | ☐ Yes | ✓ No | ☐ Unsure |
| Environmental Protection (South West Agricultural Zone Wetlands) Policy 1998 | ☐ Yes | ✓ No | ☐ Unsure |
| Perth's Bush Forever site | ☐ Yes | ✓ No | ☐ Unsure |
| Environmental Protection (Swan & Canning Rivers) Policy 1998 | ☐ Yes | ✓ No | ☐ Unsure |
| The management area as defined in s4(1) of the *Swan River Trust Act 1988* | ☐ Yes | ✓ No | ☐ Unsure |
| Which is subject to an international agreement, because of the importance of the wetland for waterbirds and waterbird habitats (e.g. Ramsar, JAMBA, CAMBA) | ☐ Yes | ✓ No | ☐ Unsure |

## 2.4 Significant Areas and/ or Land Features

2.4.1 Is the proposed development located within or adjacent to an existing or proposed National Park or Nature Reserve?

☐ Yes ☒ No **If yes**, please provide details.

The Proposal is located approximately 20 km from the nearest boundary of the Karijini National Park.

2.4.2 Are you aware of any Environmentally Sensitive Areas (as declared by the Minister under section 51B of the EP Act) that will be impacted by the proposed development?

☐ Yes ☒ No **If yes**, please provide details.

2.4.3 Are you aware of any significant natural land features (e.g. caves, ranges etc) that will be impacted by the proposed development?

☐ Yes ☒ No **If yes**, please provide details.

## 2.5 Coastal Zone Areas (Coastal Dunes and Beaches)

2.5.1 Will the development occur within 300metres of a coastal area?

(please tick) ☐ Yes **If yes**, complete the rest of this section.

☒ No **If no**, go to the next section.

2.5.2 What is the expected setback of the development from the high tide level and from the primary dune?

2.5.3 Will the development impact on coastal areas with significant landforms including beach ridge plain, cuspate headland, coastal dunes or karst?

☐ Yes ☐ No **If yes**, please describe the extent of the expected impact.

2.5.4 Is the development likely to impact on mangroves?

☐ Yes ☐ No **If yes**, please describe the extent of the expected impact.

## 2.6 Marine Areas and Biota

2.6.1 Is the development likely to impact on an area of sensitive benthic communities, such as seagrasses, coral reefs or mangroves?

☐ Yes ☒ No **If yes**, please describe the extent of the expected impact.

2.6.2 Is the development likely to impact on marine conservation reserves or areas recommended for reservation (as described in *A Representative Marine Reserve System for Western Australia*, CALM, 1994)?

☐ Yes ☒ No **If yes**, please describe the extent of the expected impact.

2.6.3 Is the development likely to impact on marine areas used extensively for recreation or for commercial fishing activities?

☐ Yes ☒ No **If yes**, please describe the extent of the expected impact, and provide any written advice from relevant agencies (e.g. Fisheries WA).

## 2.7 Water Supply and Drainage Catchments

2.7.1 Are you in a proclaimed or proposed groundwater or surface water protection area?

(You may need to contact the Department of Water (DoW) for more information on the requirements for your location, including the requirement for licences for water abstraction. Also, refer to the DoW website)

☒ Yes ☐ No **If yes**, please describe what category of area.

The Proposal is located within the Pilbara Groundwater Area proclaimed under the *Rights in Water and Irrigation Act 1914*.

2.7.2 Are you in an existing or proposed Underground Water Supply and Pollution Control area?

(You may need to contact the DoW for more information on the requirements for your location, including the requirement for licences for water abstraction. Also, refer to the DoW website)

☐ Yes ☒ No **If yes**, please describe what category of area.

2.7.3 Are you in a Public Drinking Water Supply Area (PDWSA)?

(You may need to contact the DoW for more information or refer to the DoW website. A proposal to clear vegetation within a PDWSA requires approval from DoW.)

☐ Yes ☒ No **If yes**, please describe what category of area.

2.7.4 Is there sufficient water available for the proposal?

(Please consult with the DoW as to whether approvals are required to source water as you propose. Where necessary, please provide a letter of intent from the DoW)

☒ Yes ☐ No (please tick)

2.7.5 Will the proposal require drainage of the land?

☐ Yes ☒ No **If yes**, how is the site to be drained and will the drainage be connected to an existing Local Authority or Water Corporation drainage system? Please provide details.

2.7.6 Is there a water requirement for the construction and/ or operation of this proposal?

(please tick) ☒ Yes **If yes**, complete the rest of this section.

☐ No **If no**, go to the next section.

2.7.7 What is the water requirement for the construction and operation of this proposal, in kilolitres per year?

West Angelas is considered to be a water neutral (to small deficit) site in terms of water balance; operational water demand is roughly equivalent to dewatering requirements. While the site as a whole is water neutral, the water management of each deposit is different with some in deficit and others in surplus. Water sources are integrated to ensure continuity of supply across West Angelas. This integrated water management strategy will continue to be implemented to address water supply and demand requirements for the Revised Proposal.

Refer to Section 9 of the Environmental Review Document.

2.7.8 What is the proposed source of water for the proposal? (e.g. dam, bore, surface water etc.)

Dewatering water is used on-site in the first instance to supply water for operational purposes (processing and dust suppression).

The Turee Creek B Borefield is used to provide potable water to the mine and camp facilities and, when required, water for processing purposes and dust suppression.

## 2.8 Pollution

2.8.1 Is there likely to be any discharge of pollutants from this development, such as noise, vibration, gaseous emissions, dust, liquid effluent, solid waste or other pollutants?

(please tick) ☒ Yes **If yes**, complete the rest of this section.

☐ No **If no**, go to the next section.

2.8.2 Is the proposal a prescribed premise, under the Environmental Protection Regulations 1987?

(Refer to the EPA's *General Guide for Referral of Proposals to the EPA under section 38(1) of the EP Act 1986* for more information)

☒ Yes ☐ No **If yes**, please describe what category of prescribed premise.

The Proposal is a Prescribed Premise 'by association' since it is covered by the existing West Angelas Operating Licence L7774/2000. The licence allows Category 5, 6, 63, 64, 73 and 85 activities at West Angelas.

2.8.3 Will the proposal result in gaseous emissions to air?

☒ Yes ☐ No **If yes**, please briefly describe.

The Proposal will generate Greenhouse Gas (GHG) emissions.

2.8.4 Have you done any modelling or analysis to demonstrate that air quality standards will be met, including consideration of cumulative impacts from other emission sources?

☐ Yes ☒ No **If yes**, please briefly describe.

No modelling of projected emissions was undertaken as emissions generated by the Proposal are not expected to be greater than or different to those from existing operations.

Emissions have been, and will continue to be, managed under the existing operating licence, the *Clean Energy Act 2011* (Cwth) and the *National Greenhouse and Energy Reporting Act 2007* (Cwth).

2.8.5 Will the proposal result in liquid effluent discharge?

☐ Yes ☒ No **If yes**, please briefly describe the nature, concentrations and receiving environment.

2.8.6 If there is likely to be discharges to a watercourse or marine environment, has any analysis been done to demonstrate that the State Water Quality Management Strategy or other appropriate standards will be able to be met?

☐ Yes ☒ No **If yes**, please describe.

2.8.7 Will the proposal produce or result in solid wastes?

☒ Yes ☐ No **If yes**, please briefly describe the nature, concentrations and disposal location/ method.

Waste rock will be transported by haul trucks to external waste dumps according to the material categorisation. Where practicable, waste may also be used in progressive backfilling of the pits to assist in achieving closure objectives for the site.

Refer to Section 8 of the Environmental Review Document.

2.8.8 Will the proposal result in significant off-site noise emissions?

☐ Yes ☒ No **If yes**, please briefly describe.

Noise emissions are not expected to be significantly greater than or different to those of existing operations.

2.8.9 Will the development be subject to the Environmental Protection (Noise) Regulations 1997?

☒ Yes ☐ No **If yes**, has any analysis been carried out to demonstrate that the proposal will comply with the Regulations?

Please attach the analysis.

Noise emissions will be managed under the Environmental Protection (Noise) Regulations 1997. However, previous Noise Assessments have shown that noise levels at the only sensitive receptor, the village, will not exceed Environmental Protection (Noise) Regulation thresholds.

2.8.10 Does the proposal have the potential to generate off-site, air quality impacts, dust, odour or another pollutant that may affect the amenity of residents and other "sensitive premises" such as schools and hospitals (proposals in this category may include intensive agriculture, aquaculture, marinas, mines and quarries etc.)?

☐ Yes ☒ No **If yes**, please describe and provide the distance to residences and other "sensitive premises".

The location of West Angelas is very remote, with no neighbouring mining or pastoral activities. The nearest town, Newman, is located approximately 130 km south-east of West Angelas. Therefore, impacts on sensitive receptors from nuisance dust, noise or other air quality impacts are expected to be limited.

2.8.11 If the proposal has a residential component or involves "sensitive premises", is it located near a land use that may discharge a pollutant?

☐ Yes ☐ No ☒ Not Applicable

**If yes**, please describe and provide the distance to the potential pollution source

## 2.9 Greenhouse Gas Emissions

2.9.1 Is this proposal likely to result in substantial greenhouse gas emissions (greater than 100 000 tonnes per annum of carbon dioxide equivalent emissions)?

☐ Yes ☒ No **If yes**, please provide an estimate of the annual gross emissions in absolute and in carbon dioxide equivalent figures.

West Angelas is seen as a relatively small emitter of GHG.

2.9.2 Further, if yes, please describe proposed measures to minimise emissions, and any sink enhancement actions proposed to offset emissions.

## 2.10 Contamination

2.10.1 Has the property on which the proposal is to be located been used in the past for activities which may have caused soil or groundwater contamination?

☒ Yes ☐ No ☐ Unsure **If yes**, please describe.

Deposits A west and F will be developed as satellite deposits to the existing West Angelas mining operations.

2.10.2 Has any assessment been done for soil or groundwater contamination on the site?

☒ Yes ☐ No **If yes**, please describe.

Groundwater sampling and analysis of water quality indicates that the groundwater is of good quality.

Refer to Section 9 of the Environmental Review Document.

2.10.3 Has the site been registered as a contaminated site under the *Contaminated Sites Act 2003*? (on finalisation of the CS Regulations and proclamation of the CS Act)

☐ Yes ☒ No **If yes**, please describe.

## 2.11 Social Surroundings

2.11.1 Is the proposal on a property which contains or is near a site of Aboriginal ethnographic or archaeological significance that may be disturbed?

☒ Yes ☐ No ☐ Unsure **If yes**, please describe.

Archaeological and ethnographic surveys have been undertaken over the majority of the Proposal area. To date no ethnographic sites have been identified. A number of heritage sites have been identified at both Deposits A west and F.

At Deposit A west the majority of the heritage sites include artefact scatters. Based on the current design for Deposit A west, three artefact scatters will be impacted. Section 18 consent will need to be sought for impact to these sites.

At Deposit F the sites identified include rock shelters, scarred trees and artefact scatters. A significant rock shelter containing rock art is located approximately 500m to the north of pit F2.

Based on the current design for Deposit F, one artefact scatter will be directly impacted in pit F2. Three rock shelters within immediate proximity of pit F1 may be affected by indirect impacts as a result of blasting. Additionally, a rock shelter and scarred tree located within vicinity of pit F2 may also be affected by indirect impacts. Section 18 consent for these sites will need to be sought and the rock shelters may require archaeological excavation.

Refer to Section 9 of the Environmental Review Document.

2.11.2 Is the proposal on a property which contains or is near a site of high public interest (e.g. a major recreation area or natural scenic feature)?

☐ Yes ☒ No **If yes**, please describe.

The Proposal is an extension to an existing, very remote mining operation, located within an area where the dominant land uses are pastoral and mining.

There are no significant features that warrant public interest.

2.11.3 Will the proposal result in or require substantial transport of goods, which may affect the amenity of the local area?

☐ Yes ☒ No **If yes**, please describe.

## 3. PROPOSED MANAGEMENT

### 3.1 Principles of Environmental Protection

3.1.1 Have you considered how your project gives attention to the following Principles, as set out in section 4A of the EP Act? (For information on the Principles of Environmental Protection, please see EPA Position Statement No. 7, available on the EPA website)

| | | |
|---|---|---|
| 1. The precautionary principle. | ☒ Yes | ☐ No |
| 2. The principle of intergenerational equity. | ☒ Yes | ☐ No |
| 3. The principle of the conservation of biological diversity and ecological integrity. | ☒ Yes | ☐ No |
| 4. Principles relating to improved valuation, pricing and incentive mechanisms. | ☒ Yes | ☐ No |
| 5. The principle of waste minimisation. | ☒ Yes | ☐ No |

Refer to Section 13 of the Environmental Review Document

3.1.2 Is the proposal consistent with the EPA's Environmental Protection Bulletins/Position Statements and Environmental Assessment Guidelines/Guidance Statements (available on the EPA website)?

☒ Yes ☐ No

### 3.2 Consultation

3.2.1 Has public consultation taken place (such as with other government agencies, community groups or neighbours), or is it intended that consultation shall take place?

☒ Yes ☐ No **If yes**, please list those consulted and attach comments or summarise response on a separate sheet.

Refer to Section 3 of the Environmental Review Document.

**THIS DOCUMENT**

This document has been produced by the Office of the Appeals Convenor as an electronic version of the original Statement for the proposal listed below as signed by the Minister and held by this Office. Whilst every effort is made to ensure its accuracy, no warranty is given as to the accuracy or completeness of this document.

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Published on: 12 June 2014 Statement No: 970

# STATEMENT TO AMEND CONDITIONS APPLYING TO A PROPOSAL (PURSUANT TO THE PROVISIONS OF SECTION 46 OF THE *ENVIRONMENTAL PROTECTION ACT 1986*)

West Angelas Iron Ore Project

**Proposal:** The development of iron ore mines at Deposits 'A', 'B', and 'E', waste dumps, ore processing operation and associated infrastructure at West Angelas, 130 kilometres west of Newman, and rail infrastructure, as documented in Schedule 1 of this Ministerial Statement.

**Proponent:** Robe River Mining Co. Pty. Ltd.

**Proponent Address:** 152-158 St Georges Terrace
PERTH WA 6000
GPO Box A42, PERTH WA 6001

**Assessment Number:** 1914

**Previous Assessment Number:** 1144

**Report of the Environmental Protection Authority:** 1508

**Previous Report of the Environmental Protection Authority:** 924

**Previous Ministerial Statement Number:** 514

The implementation of the proposal to which the above report of the Environmental Protection Authority relates is subject to the following conditions and procedures, which replace and supersede all previous conditions of Ministerial Statement 514.

## 1 Proposal Implementation

1-1 When implementing the proposal, the proponent shall not exceed the authorised extent of the proposal as defined in Column 3 of Table 2 in Schedule 1, unless amendments to the proposal and the authorised extent of the proposal have been approved under the *Environmental Protection Act 1986*.

## 2 Contact Details

2-1 The proponent shall notify the Chief Executive Officer (CEO) of any change of its name, physical address or postal address for the serving of notices or other correspondence within 28 days of such change. Where the proponent is a corporation or an association of persons, whether incorporated or not, the postal address is that of the principal place of business or of the principal office in the State.

## 3 Compliance Reporting

3-1 The proponent shall prepare and maintain a Compliance Assessment Plan to the satisfaction of the CEO.

3-2 The proponent shall submit to the CEO the Compliance Assessment Plan required by condition 3-1 prior to the first Compliance Assessment Report required by condition 3-6.

The Compliance Assessment Plan shall indicate:

(1) the frequency of compliance reporting;

(2) the approach and timing of compliance assessments;

(3) the retention of compliance assessments;

(4) the method of reporting of potential non-compliance and corrective actions to take;

(5) the table of contents of Compliance Assessment Reports; and

(6) public availability of Compliance Assessment Reports.

3-3 The proponent shall assess compliance with conditions in accordance with the Compliance Assessment Plan required by condition 3-1.

3-4 The proponent shall retain reports of all compliance assessments described in the Compliance Assessment Plan required by condition 3-1 and shall make those reports available when requested by the CEO.

3-5 The proponent shall advise the CEO of any potential non-compliance within seven days of that non-compliance being known.

3-6 The proponent shall submit to the CEO Compliance Assessment Reports addressing compliance in the previous calendar year. Compliance Assessment Reports shall be submitted by the submission date defined in the Compliance Assessment Plan required by condition 3-1.

The Compliance Assessment Report shall:

(1) be endorsed by the proponent's Managing Director/ General Manager/ Chief Executive Officer or a person delegated to sign on the Managing Director's/ General Manager's/ Chief Executive Officer's behalf;

(2) include a statement as to whether the proponent has complied with the conditions;

(3) identify all potential non-compliances and describe corrective and preventive actions taken;

(4) be made publicly available in accordance with the approved Compliance Assessment Plan; and

(5) indicate any proposed changes to the Compliance Assessment Plan required by condition 3-1.

## 4 Public Availability of Data

4-1 Subject to condition 4-2, within a reasonable time period, approved by the CEO, of the issue of this statement and for the remainder of the life of the proposal, the proponent shall make publicly available, in a manner approved by the CEO, all validated environmental data (including sampling design, sampling methodologies, empirical data and derived information products (e.g. maps)) relevant to the assessment of this proposal and implementation of this statement.

4-2 If any data referred to in condition 4-1 contains particulars of:

(1) a secret formula or process; or

(2) confidential commercially sensitive information;

the proponent may submit a request for approval from the CEO to not make this data publicly available. In making such a request, the proponent shall provide the CEO with an explanation and reasons why the data should not be made publicly available.

## 5 Environmental Management Program

5-1 The proponent shall implement the proposal in accordance with the "*Environmental Management Program*", dated November 2013, or subsequent revisions approved by the CEO.

The Environmental Management Program consists of the following Management Plans:

(1) Groundwater Management Plan;

(2) Surface Water Management Plan;

(3) Vegetation and Flora Management Plan;

(4) Fauna Management Plan;

(5) Dust Management Plan;

(6) Waste Management Plan; and

(7) Rail Management Plan.

Each Management Plan includes:

i. the specific environmental objectives and targets for each environmental factor;

ii. the management measures to be applied to avoid and minimise the environmental impact of the proposal;

iii. monitoring measures to measure the performance of management against targets; and

iv. contingency measures to mitigate impacts.

5-2 The proponent shall make the Environmental Management Program required by condition 5.1 publicly available, in a manner approved by the CEO.

## 6 Groundwater

6-1 The proponent shall manage groundwater abstraction and dewatering activities to ensure minimal adverse impacts on the availability and quality of groundwater resources and the dependent ecology.

6-2 To verify that the requirements of condition 6-1 are met the proponent shall undertake monitoring of groundwater level elevations and quality as outlined in the Groundwater Management Plan approved as part of Environmental Management Program required by condition 5.

6-3 In the event that the monitoring required by condition 6-2 indicates that the requirements of condition 6-1 are not met, the proponent shall implement contingency actions as outlined in the Groundwater Management Plan.

6-4 The proponent shall submit annually the results of monitoring required by condition 6-2 to the CEO of the Office of the Environmental Protection Authority as part of the compliance assessment reports required by condition 3-6.

## 7 Surface Water Drainage

7-1 The proponent shall manage surface water drainage and discharge to ensure minimal adverse impacts on existing surface water drainage patterns or the water dependent ecosystems.

7-2 To verify that the requirements of condition 7-1 are met, the proponent shall undertake monitoring of the quality and quantity of water discharge as outlined in the Surface Water Management Plan approved as part of the Environmental Management Program required by condition 5.

7-3 In the event that the monitoring required by condition 7-2 indicates that the requirements of condition 7-1 are not met, the proponent shall implement contingency actions as outlined in the Surface Water Management Plan.

7-4 The proponent shall submit annually the results of monitoring required by condition 7-2 to the CEO as part of the Compliance Assessment Reports required by condition 3-6.

## 8 Conservation Significant Communities and Species

8-1 The proponent shall manage clearing activities to ensure minimal adverse impacts on conservation significant communities and species.

8-2 To verify that the requirements of condition 8-1 are met, the proponent shall implement the proposal in accordance with the Vegetation and Flora Management Plan and Fauna Management Plan approved as part of the Environmental Management Program required by condition 5.

8-3 In the event that monitoring required by the Management Plans detailed in condition 8-2 indicates that the specific environmental objectives and targets, identified for each environmental factor, have been exceeded, the proponent shall:

(1) within 7 days of becoming aware of the exceedance, implement contingency measures as outlined in the management plans and continue implementation until environmental objectives and targets are being met, or as otherwise agreed by the CEO; and

(2) within 14 days of becoming aware of the exceedance, submit details of contingency measures implemented to the CEO.

## 9 Rehabilitation and closure

9-1 The proponent shall ensure that the mine is closed, decommissioned and rehabilitated in an ecologically sustainable manner, consistent with agreed post-mining outcomes and land uses, and without unacceptable liability to the State of Western Australia.

9-2 The proponent shall prepare a Mine Closure Plan for the West Angelas Iron Ore Project.

9-3 The Mine Closure Plan required by condition 9-2 shall:

(1) when implemented, manage the implementation of the proposal to meet the requirements of condition 9-1;

(2) be prepared in accordance with the *Guidelines for Preparing Mine Closure Plans*, *June 2011* (Department of Mines and Petroleum and Environmental Protection Authority) or its revisions; and

(3) be to the requirements of the CEO on advice of the Department of Mines and Petroleum.

9-4 Within 12 months of commissioning of additional mine pits or as otherwise agreed by the CEO the proponent shall implement the approved Mine Closure Plan and continue implementation until otherwise agreed by the CEO.

9-5 Revisions to the Mine Closure Plan may be approved by the CEO on the advice of the Department of Mines and Petroleum.

9-6 The proponent shall implement revisions of the Mine Closure Plan required by condition 9-5.

[Signed 11 June 2014]

**HON ALBERT JACOB MLA**
**MINISTER FOR ENVIRONMENT; HERITAGE**

**Schedule 1**

**Table 1: Summary of the Proposal**

| | |
|---|---|
| **Proposal title** | West Angelas Iron Ore Project |
| **Proponent name** | Robe River Mining Co. Pty. Ltd. |
| **Short description** | Development and operation of an open-cut iron ore mine and associated infrastructure at the West Angelas Iron Ore Mine, 130 kilometres west of Newman in the Pilbara region (Figure 1). Iron ore is to be mined from above and below the water table in Deposits A, B and E. The general lay out of the mine and facilities are documented in Figure 2.<br><br>The mining operations are supplied with water from the mine dewatering bores and water from the Turee Creek B Borefield, located approximately 30 kilometres west of the minesite.<br><br>Railway infrastructure from West Angelas to the port facilities at Cape Lambert (Figure 3). |

**Table 2: Location and authorised extent of physical and operational elements**

| **Column 1** | **Column 2** | **Column 3** |
|---|---|---|
| **Element** | **Location** | **Authorised Extent** |
| Mining Area (deposits A, B and E) | Figure 2 | Clearing of no more than 2,260 hectares (ha) within a 19,853 ha development envelope. |
| Waste Dumps | Figure 2 | Clearing of no more than 1,407 ha within a 19,853 ha development envelope. |
| Associated infrastructure, access and accommodation | Figure 2 | Clearing of no more than 1,000 ha within a 19,853 ha development envelope. |

**Figures (attached)**

Figure 1 – Regional Location of West Angelas

Figure 2 – West Angelas Iron Ore Mine Indicative Layout and Approval Outline

Figure 3 – West Angelas Railway

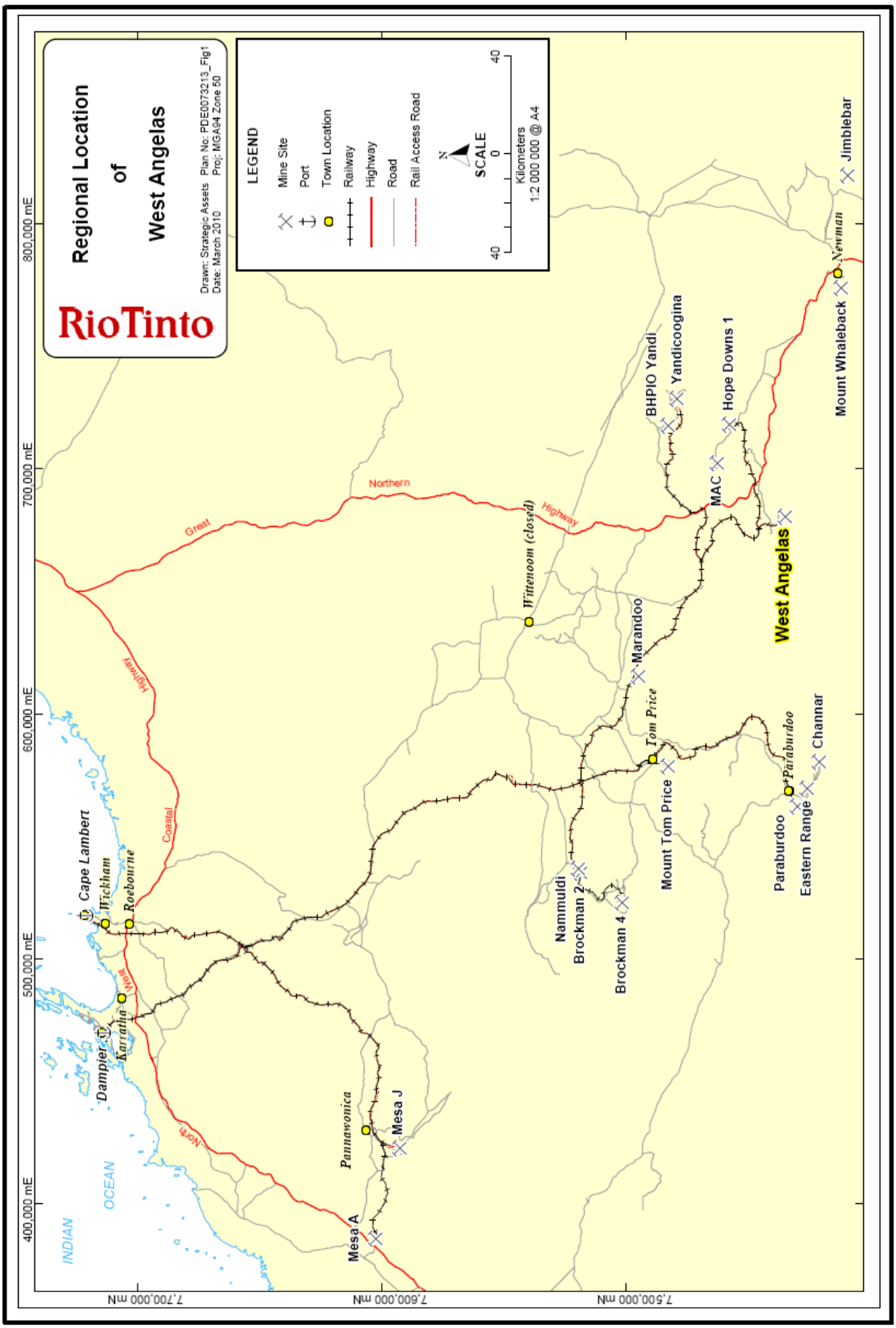


Figure 1: Regional Location of West Angelas

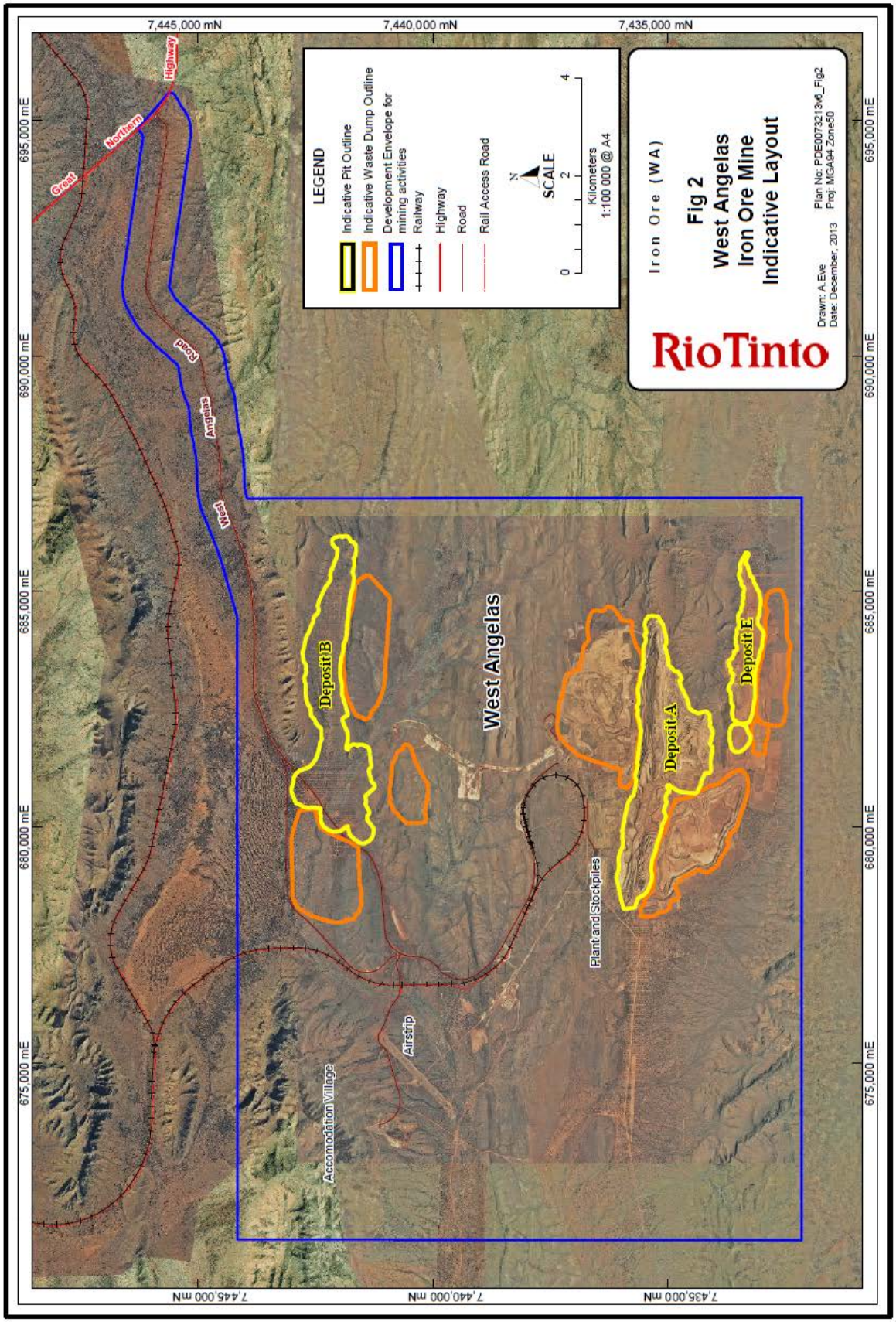


Figure 2: West Angelas Iron Ore Mine Development Envelope and Indicative Layout

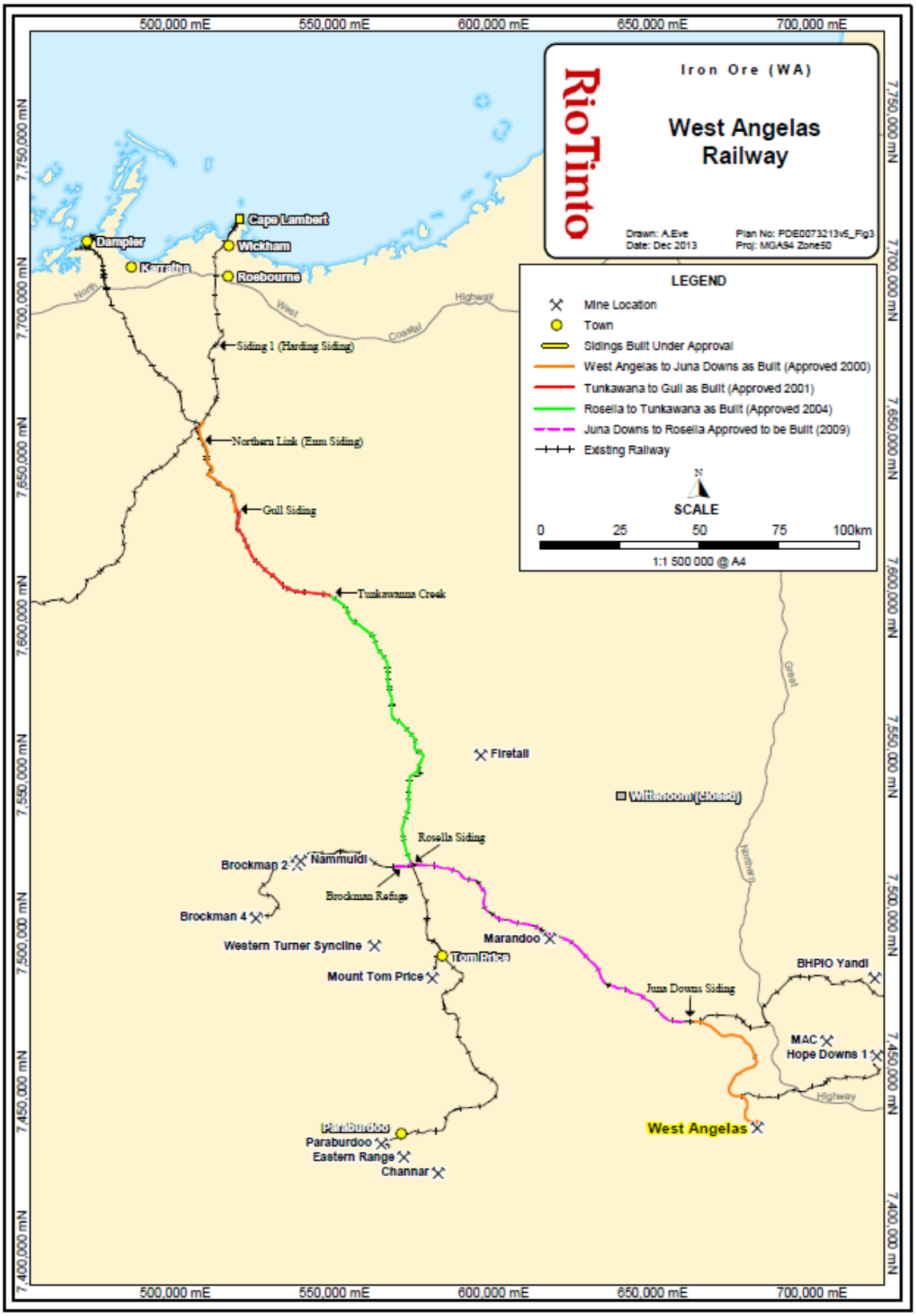


Figure 3: West Angelas Railway

**Schedule 2**

## West Angelas Iron Ore Project

Coordinates defining the development envelope are held by the Office of the Environmental Protection Authority, dated 31 December 2013.

**Schedule 3**

## Notes

The following notes are provided for information and do not form a part of the implementation conditions of the Statement:

- The proponent for the time being nominated by the Minister for Environment under section 38(6) of the *Environmental Protection Act 1986* is responsible for the implementation of the proposal unless and until that nomination has been revoked and another person is nominated.

- If the person nominated by the Minister, ceases to have responsibility for the proposal, that person is required to provide written notice to the Environmental Protection Authority of its intention to relinquish responsibility for the proposal and the name of the person to whom responsibility for the proposal will pass or has passed. The Minister for Environment may revoke a nomination made under section 38(6) of the *Environmental Protection Act 1986* and nominate another person.

- To initiate a change of proponent, the nominated proponent and proposed proponent are required to complete and submit Post Assessment Form 1 – Application to Change Nominated Proponent.

- The General Manager of the Office of the Environmental Protection Authority was the Chief Executive Officer of the Department of the Public Service of the State responsible for the administration of section 48 of the *Environmental Protection Act 1986* at the time the Statement was signed by the Minister for Environment.

APRIL 2013



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# RIO TINTO
# GREATER WEST ANGELAS
# VEGETATION AND FLORA ASSESSMENT

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# ACRONYMS

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

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# EXECUTIVE SUMMARY

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

**Methods**

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

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

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

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

**Flora**

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

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

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

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

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

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

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

**Vegetation**

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

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

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

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

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

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

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

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

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

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

**Conclusions**

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

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

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# 1 INTRODUCTION

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

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

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

## 1.1 LEGISLATIVE FRAMEWORK

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

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

- The Precautionary Principle

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

- The Principles of Intergenerational Equity

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

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

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

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

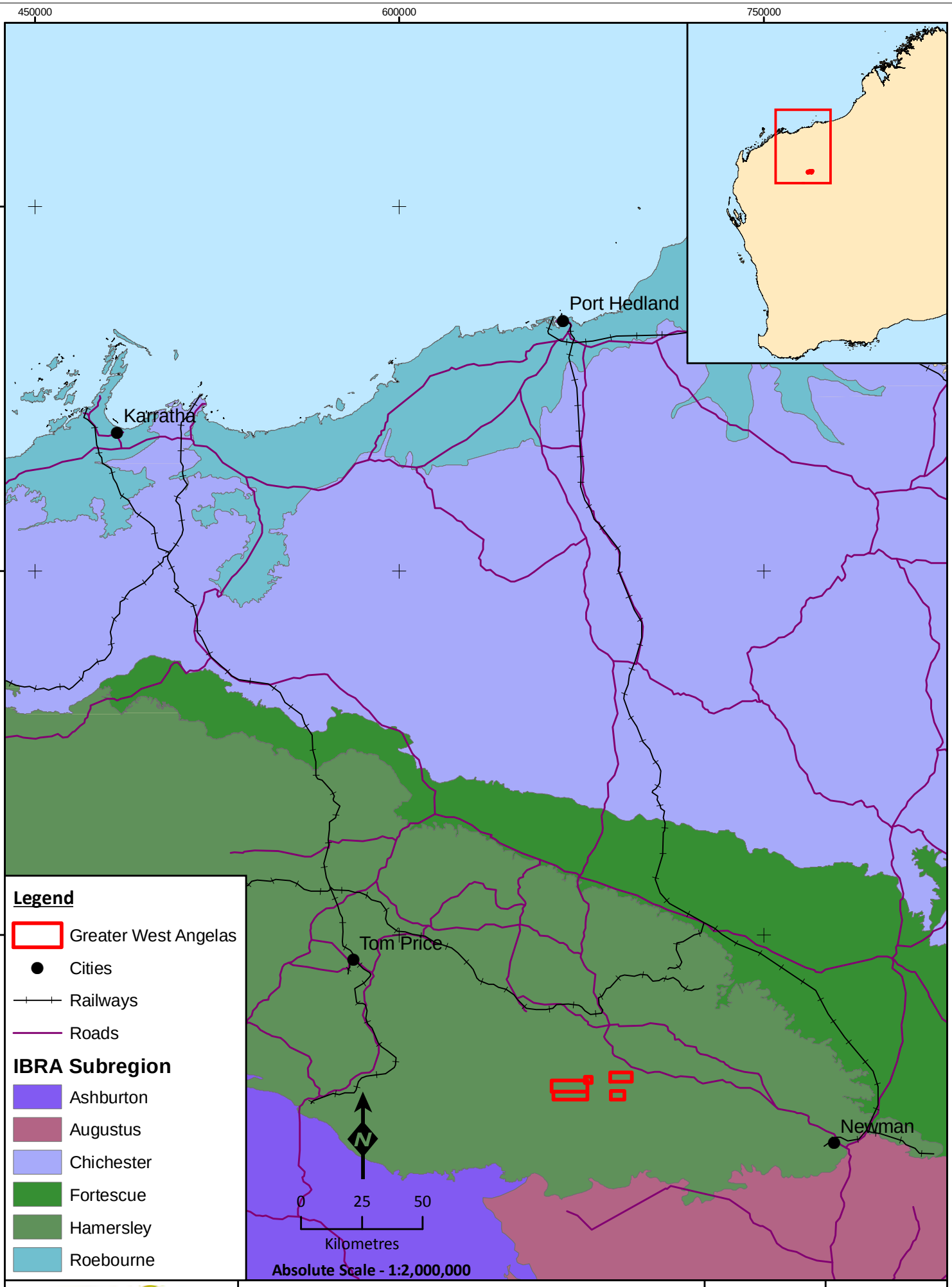
- Environmental Protection Authority's (EPA's) Position Statement No. 3: Terrestrial Biological Surveys as an Element of Biodiversity Protection (Environmental Protection Authority 2002); and

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

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

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

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

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# Location of West Angelas and IBRA Subregions

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

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

Unique Map ID: CP098

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## 1.2 SURVEY OBJECTIVES

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

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

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

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

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

# 2 EXISTING ENVIRONMENT

## 2.1 CLIMATE

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

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

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

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

**Table 2.1 – Rainfall at Turee Creek and Paraburdoo meteorological stations**

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

(BOM 2011)

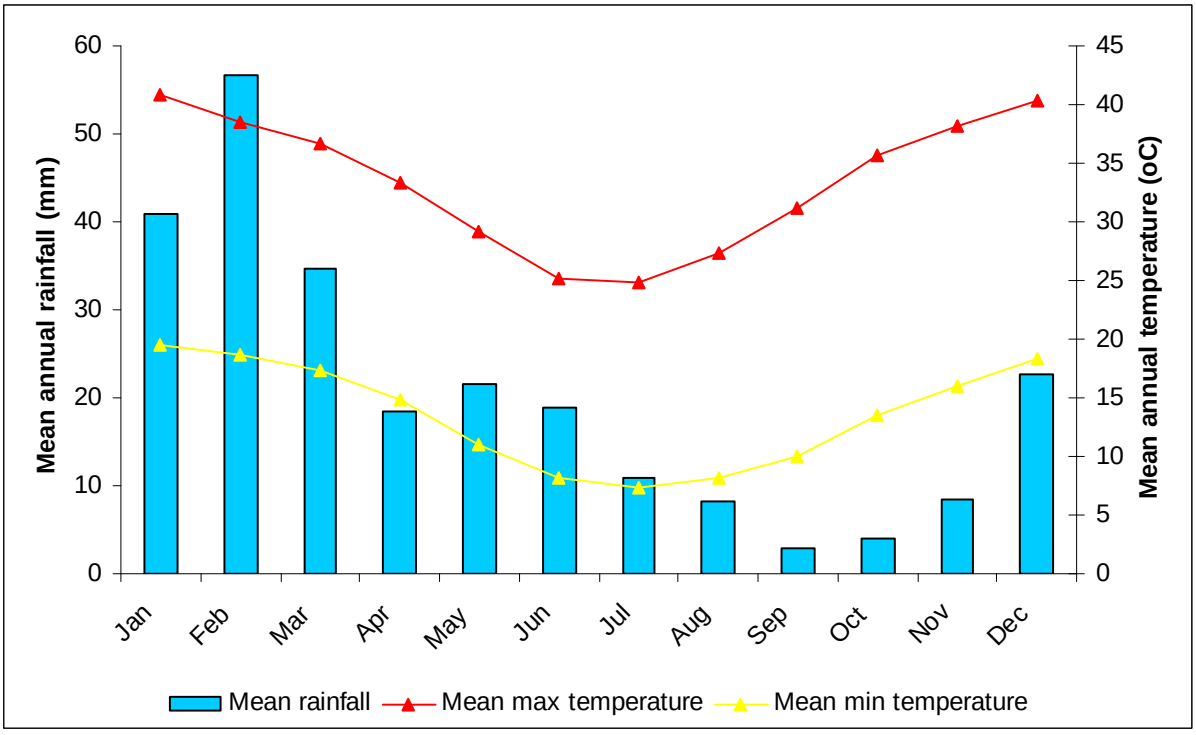


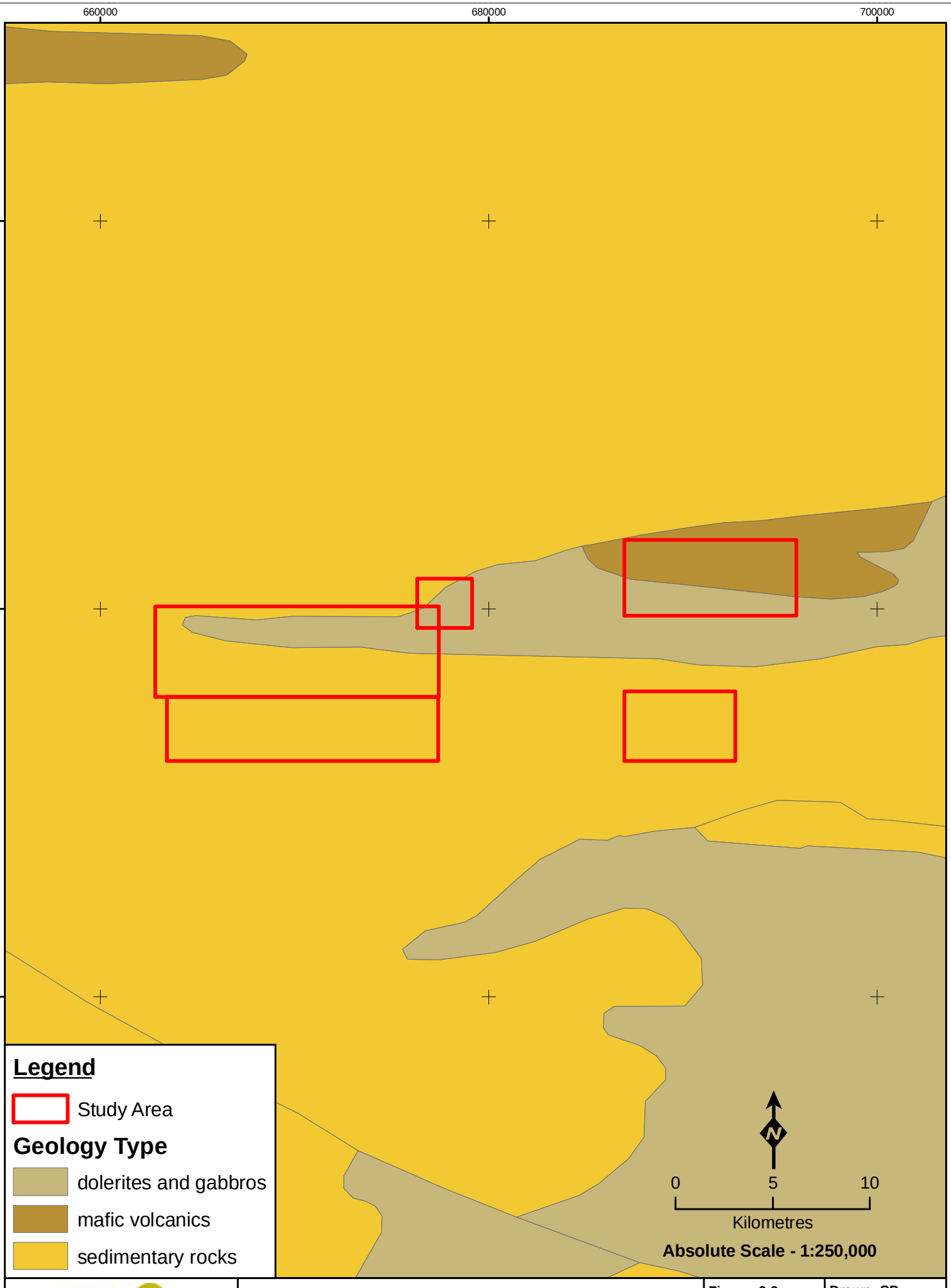

**Figure 2.1 – Mean monthly climate data for Turee Creek (temperature from Paraburdoo Aero)**

## 2.2 GEOLOGY, LAND SYSTEMS AND SOILS

### 2.2.1 Geology

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

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

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# Geology of West Angelas Study Area

**Figure: 2.2**
**Project ID: 1457**

**Drawn: CP**
**Date: 04/09/2012**

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

Unique Map ID: CP099

**A4**

**Table 2.2 – Geology of West Angelas Study Area**

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

### 2.2.2 Soils

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

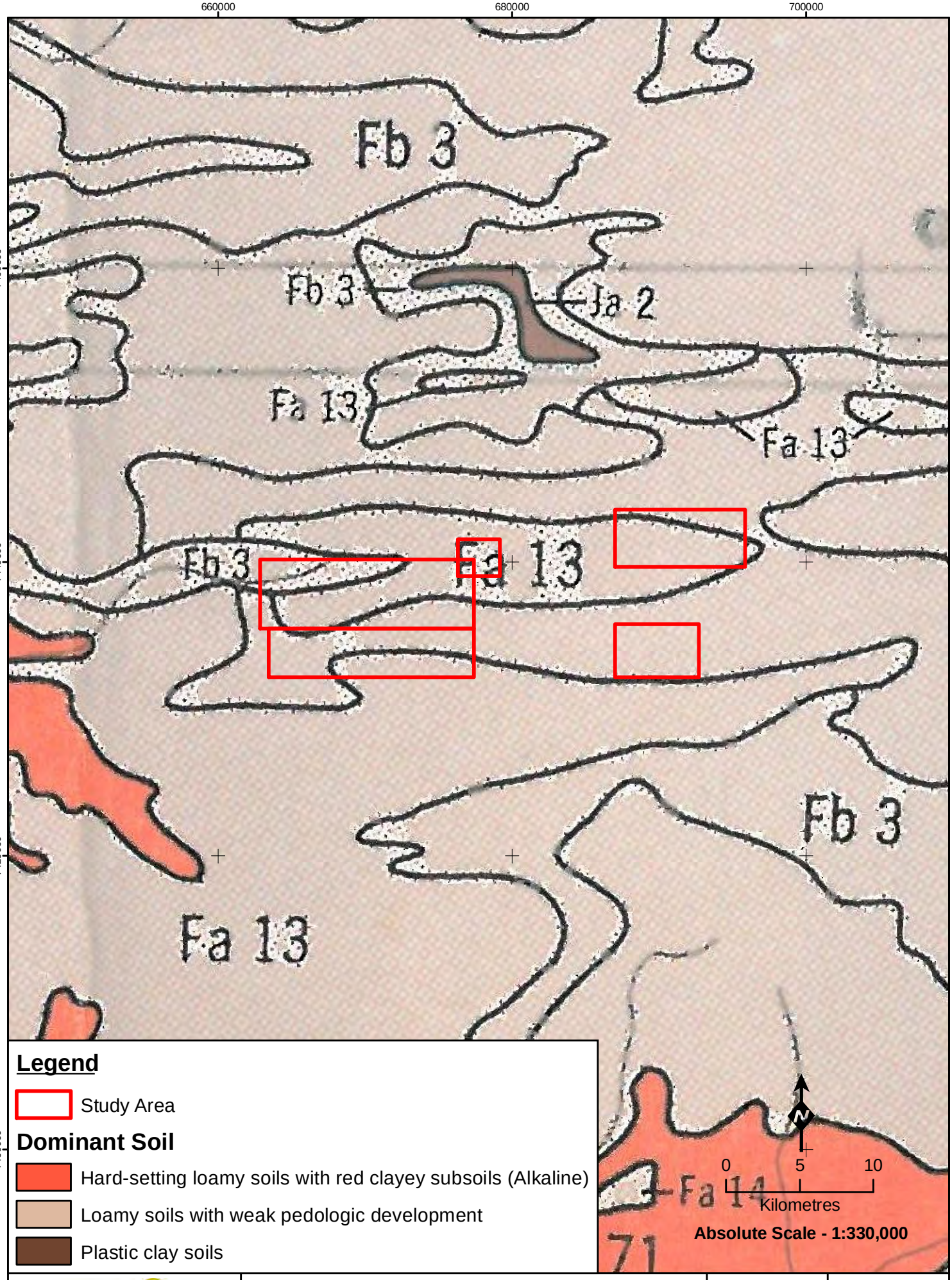
The most extensive soils in the Pilbara are shallow, stony soils on hills and ranges and sands on sandplains. In the south, the soils are predominantly red earths overlying hardpan on level to gently inclined plains. Lower flood plains have cracking and non-cracking clay soils. Duplex (texture-contrast)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

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

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

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

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

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# Soils of West Angelas Study Area

**Figure: 2.3**
**Project ID: 1457**
**Drawn: CP**
**Date: 04/09/2012**

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

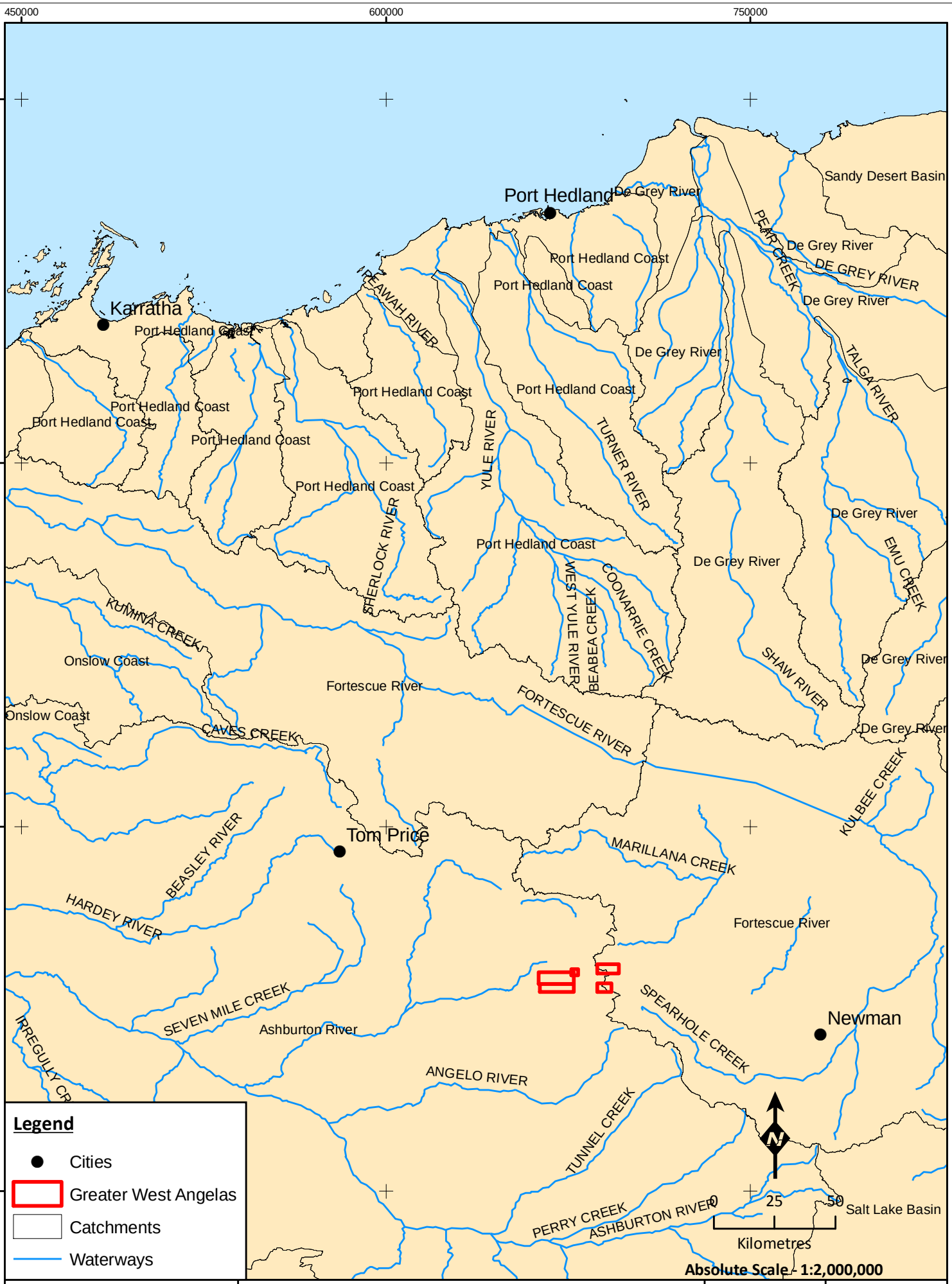
Unique Map ID: CP100

**A4**

## 2.3 HYDROGEOLOGY

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

The Study Area is located in the Hamersley Range, and is a part of both the Ashburton and the Fortescue Catchments. The closest creek to the Study Area is Turee Creek, a sub-tributary of the Ashburton River. Turee Creek flows west along a 4 km wide valley before turning sharply to exit the Hamersley Range (Johnson and Wright 2001). The West Angelas mine and Study Area are situated in the East Turee Creek catchment (Figure 2.4). The Turee Creek East drainage is fed by a number of smaller creeks originating in the hills to the west (Johnson and Wright 2001). The creek system is ephemeral and does not support any permanent surface-water features (Johnson and Wright 2001). The main aquifer in the area is the vuggy pisolite (Robe Pisolite) which overlies fractured basement rocks of the Woongarra volcanics and Boolgeeda Iron Formations (Johnson and Wright 2001). This aquifer lies within tertiary paleochannels and the aquifer zone varies between 50 and 80 m in thickness and has an estimated permeability of 40-80 m per day (Johnson and Wright 2001).


450000
600000
750000
7800000
7650000
7500000
7350000
Port Hedland
Karratha
Tom Price
Newman
Sandy Desert Basin
De Grey River
Port Hedland Coast
REAWIAH RIVER
PEAR CREEK
DE GREY RIVER
TALGA RIVER
YULE RIVER
TURNER RIVER
SHERLOCK RIVER
WEST YULE RIVER
BEABEA CREEK
COONARRIE CREEK
EMU CREEK
SHAW RIVER
KUMINA CREEK
Onslow Coast
Fortescue River
FORTESCUE RIVER
CAVES CREEK
KULBEE CREEK
BEASLEY RIVER
HARDEY RIVER
MARILLANA CREEK
SEVEN MILE CREEK
Ashburton River
SPEARHOLE CREEK
IRREGULLY CR
ANGELO RIVER
TUNNEL CREEK
PERRY CREEK
ASHBURTON RIVER
Salt Lake Basin
0
25
50
Kilometres
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Legend
Cities
Greater West Angelas
Catchments
Waterways
Absolute Scale - 1:2,000,000
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ENVIRONMENT
Location of West Angelas and Regional Hydrology
Figure: 2.4
Project ID: 1457
Drawn: CP
Date:13/06/2012
Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994
Unique Map ID: CP085
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## 2.4 LAND USE HISTORY

### 2.4.1 Overview

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

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

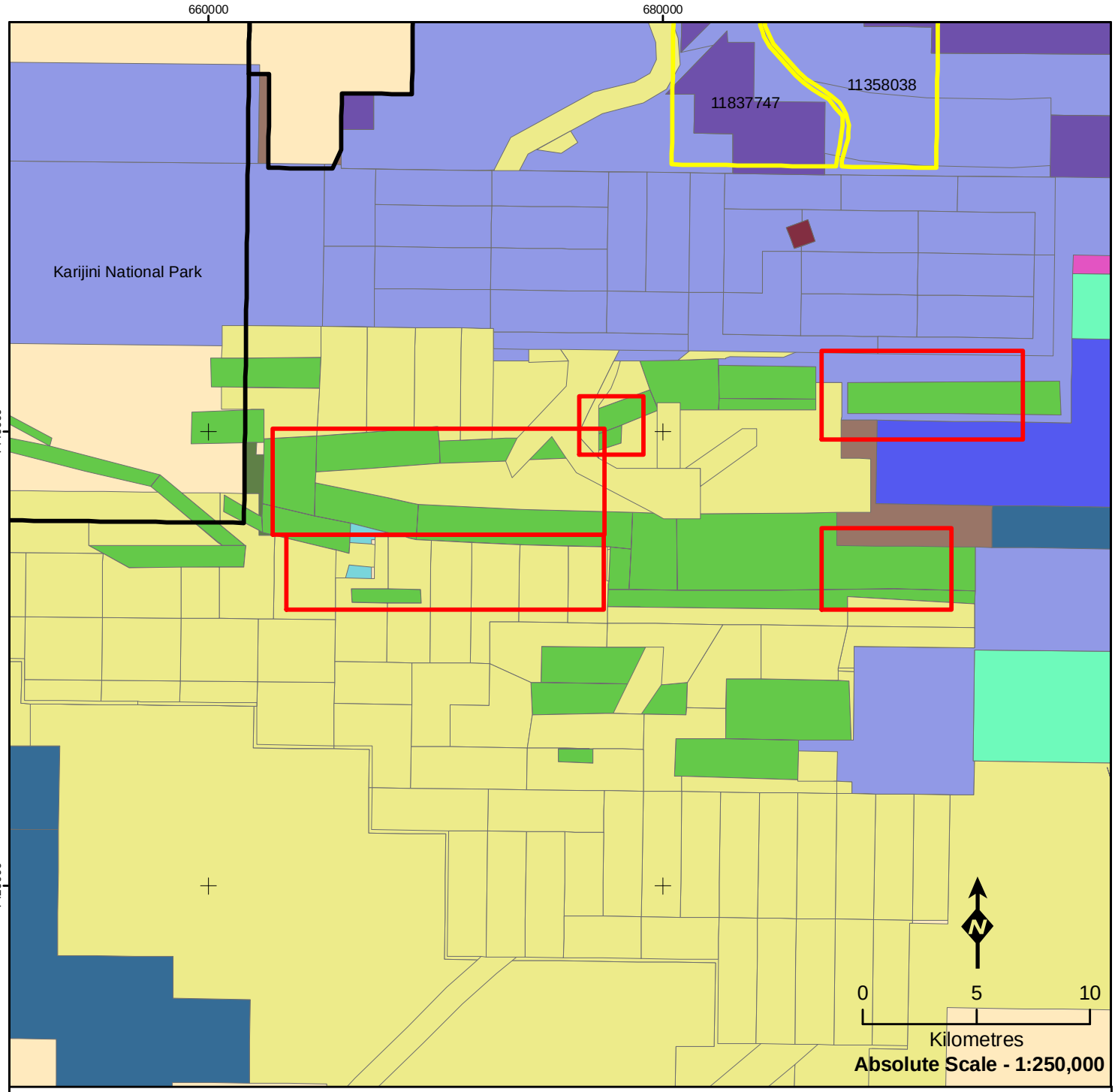
The total area of unallocated Crown land within the Pilbara bioregion is 496 $km^2$ (0.28%).

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

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

### 2.4.2 Local Land Use

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




## Legend

- Study Area
- Conservation Reserves
- Pastoral Lease Boundaries

### Mining Tenements

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

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# Local Land Use of West Angelas Study Area

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

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

Unique Map ID: CP101

**A4**

## 2.5 PILBARA BIOGEOGRAPHIC REGION

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

## 2.6 LAND SYSTEMS

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

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

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

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

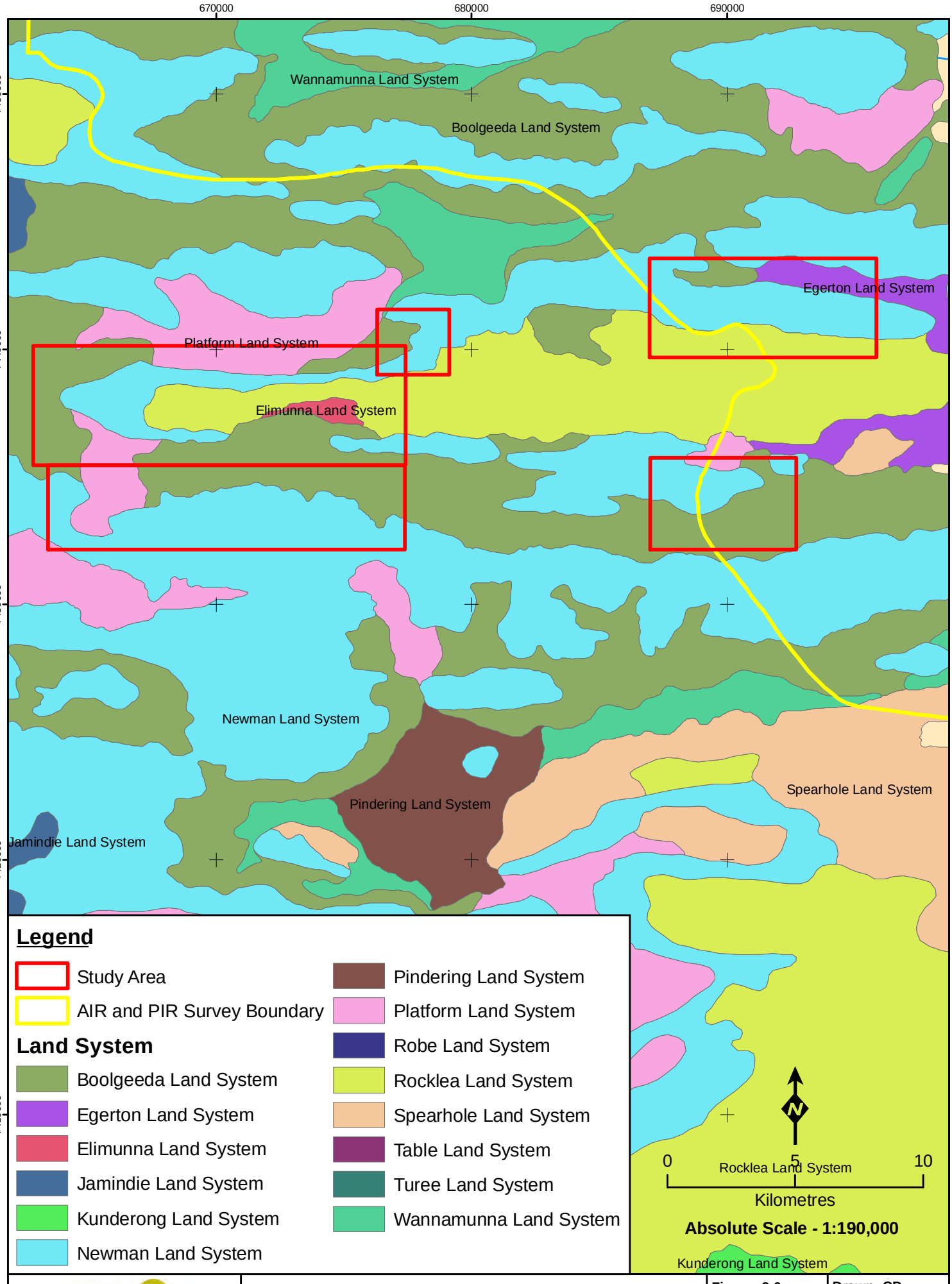
**Table 2.3 – Extent of land systems present within the Study Area**

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

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

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

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

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# Land Systems of West Angelas Study Area

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

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

Unique Map ID: CP103

**A4**

## 2.7 THREATENED ECOLOGICAL COMMUNITIES

### 2.7.1 Commonwealth Threatened Ecological Communities

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

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

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

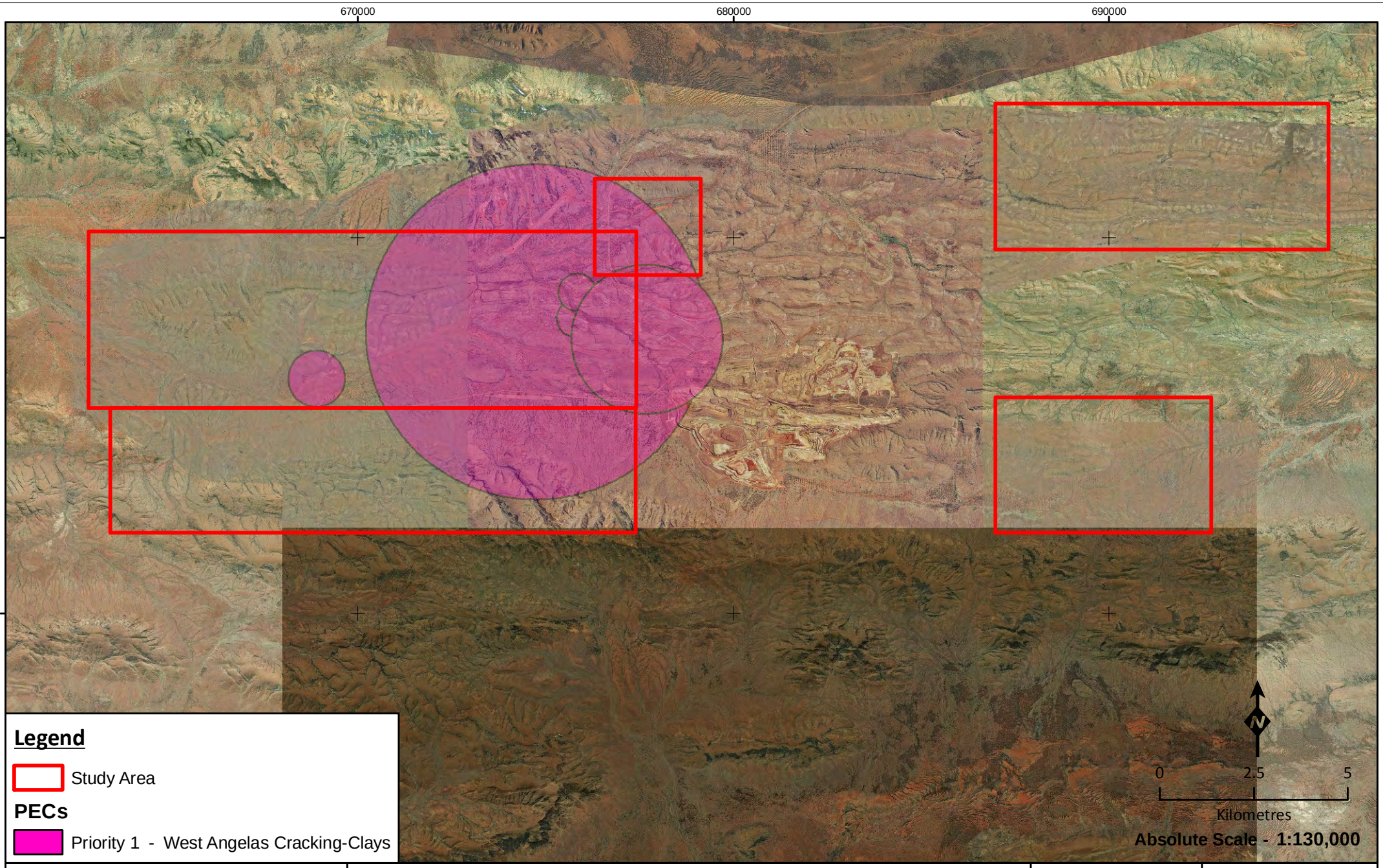
### 2.7.2 State Threatened Ecological Communities

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

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

### 2.7.3 State Priority Ecological Communities

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

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# PECs of the West Angelas Study Area

**Figure: 2.7**
**Project ID: 1457**

**Drawn: CP**
**Date: 20/09/2012**

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

Unique Map ID: CP138

**A4**

## 2.8 PREVIOUS VEGETATION SURVEYS

### 2.8.1 Beard Vegetation Descriptions

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

**Table 2.4 – Vegetation association codes.**

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

### 2.8.2 Finer Scale Vegetation Surveys

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

**Table 2.5 – Previous Vegetation Surveys at Greater West Angelas**

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

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

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

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

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

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

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

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

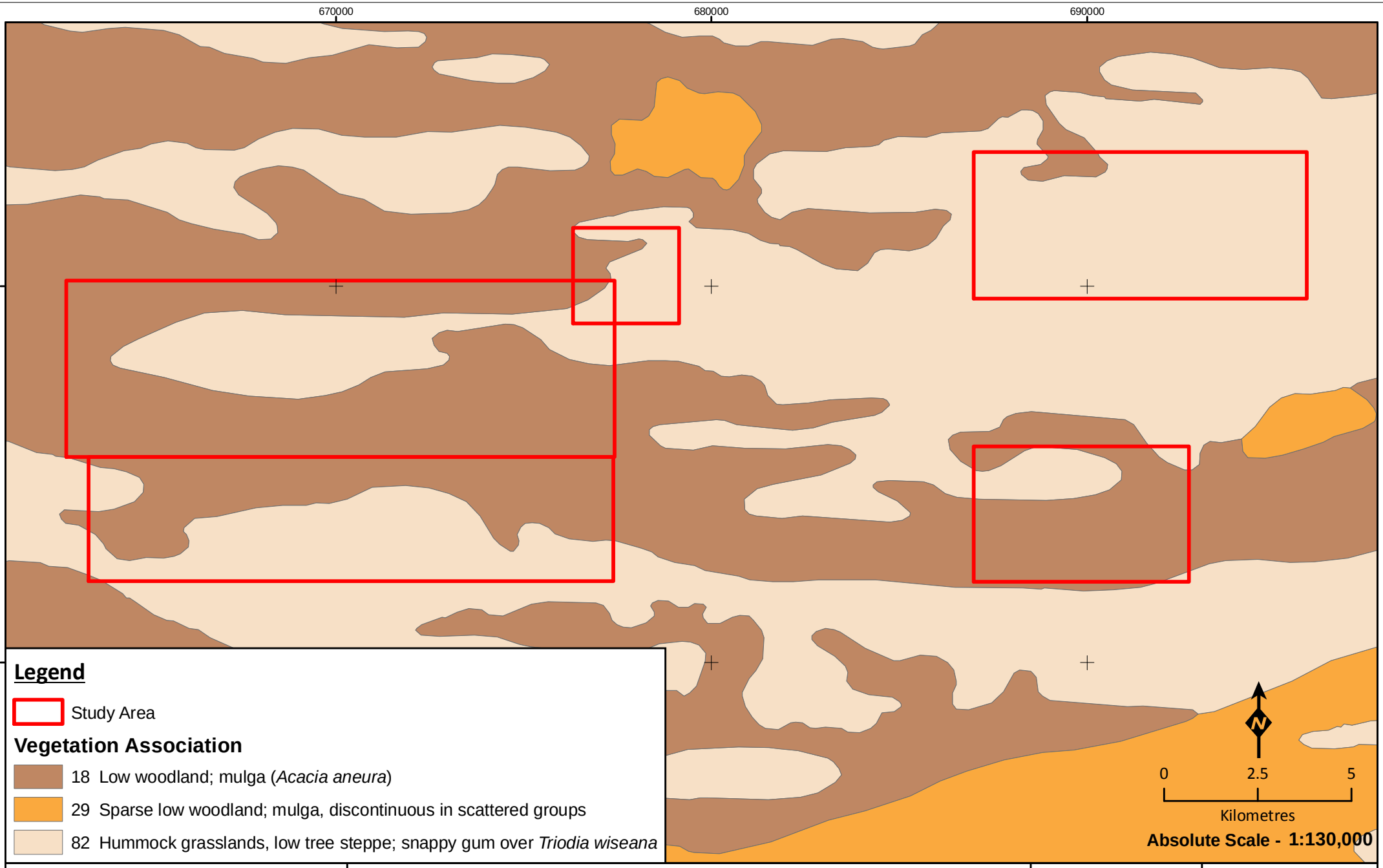
| Biota (2010) | | | Biota (2006) | | | ME Trudgen & Associates(1998) | | |
|---|---|---|---|---|---|---|---|---|
| **Unit** | **Description** | **Area (ha)** | **Unit** | **Description** | **Area (ha)** | **Unit** | **Description** | **Area (ha)** |
| *AanAprRHeE RfoTHtTlo* | *Acacia aneura*, *A. pruinocarpa*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

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

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

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

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

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

**Figure: 2.8**
**Project ID: 1457**

**Drawn: CP**
**Date: 16/10/2012**

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

Unique Map ID: CP104

**A4**

### 2.8.3 Previous Records of Priority Flora at West Angelas

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

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

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

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

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

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

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

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

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

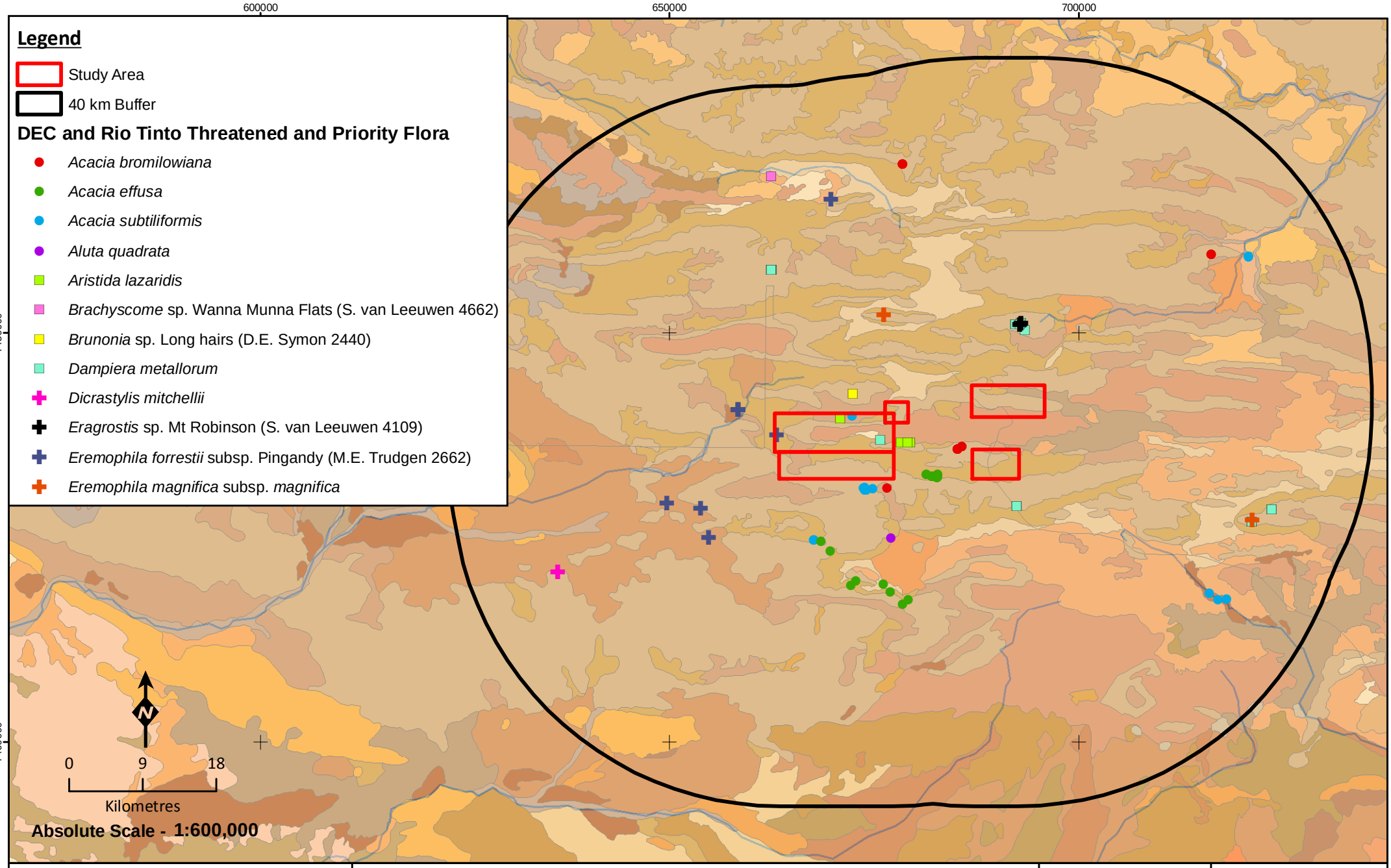
| Conservation Status | Taxon | Family | Source | Bio-region | Habitat (WA Herbarium 2012) | Nearest Localities or Towns | Flowering Period | Likelihood of Occurrence |
|---|---|---|---|---|---|---|---|---|
| 3 | *Eremophila magnifica* subsp. *velutina* | Scrophulariaceae | WAHERB, DRF, DEC | PILB |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

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

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

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

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

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

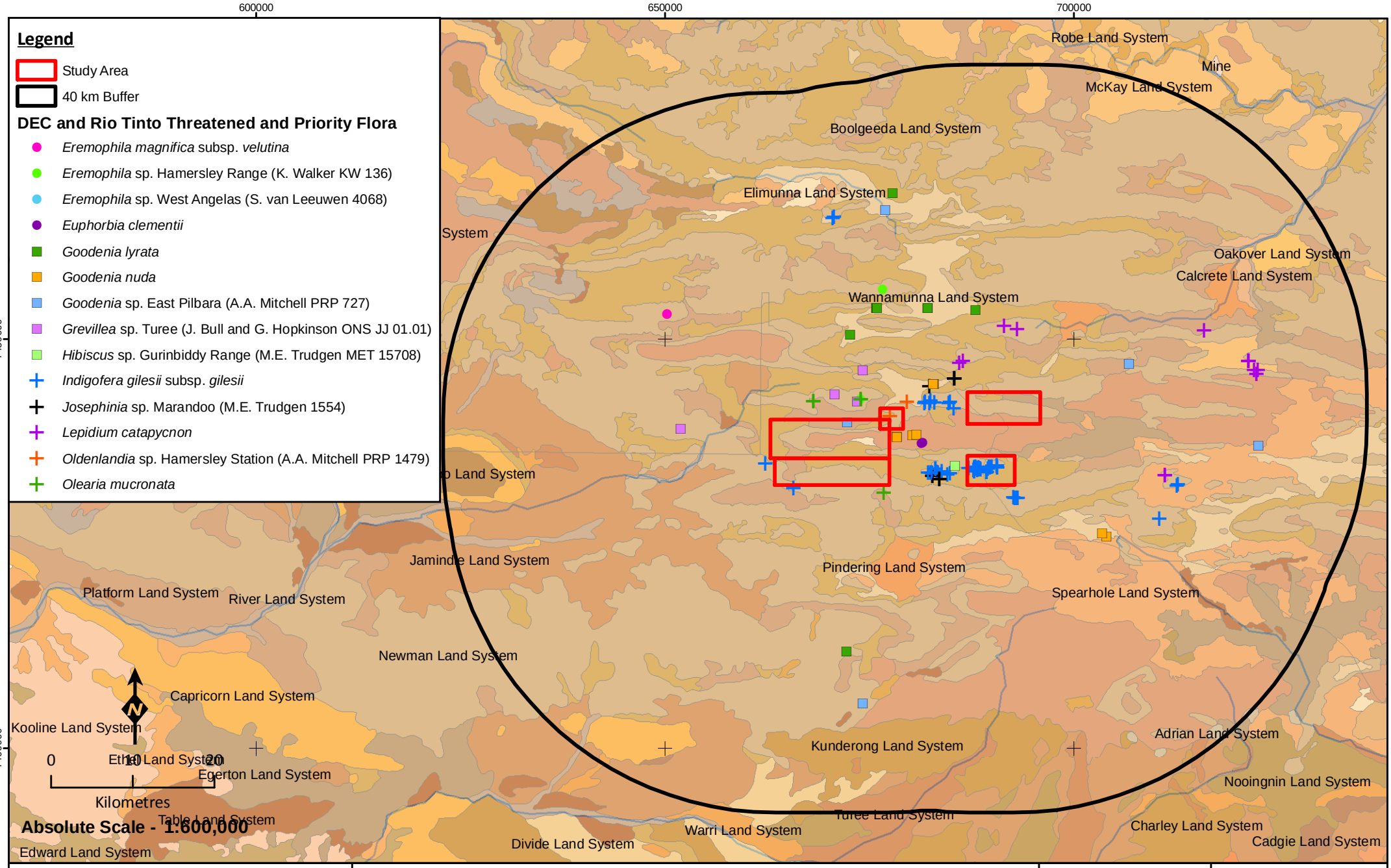
**Figure: 2.9**
**Project ID: 1457**

**Drawn: CP**
**Date: 19/09/2012**

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

Unique Map ID: CPXXX

**A4**

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

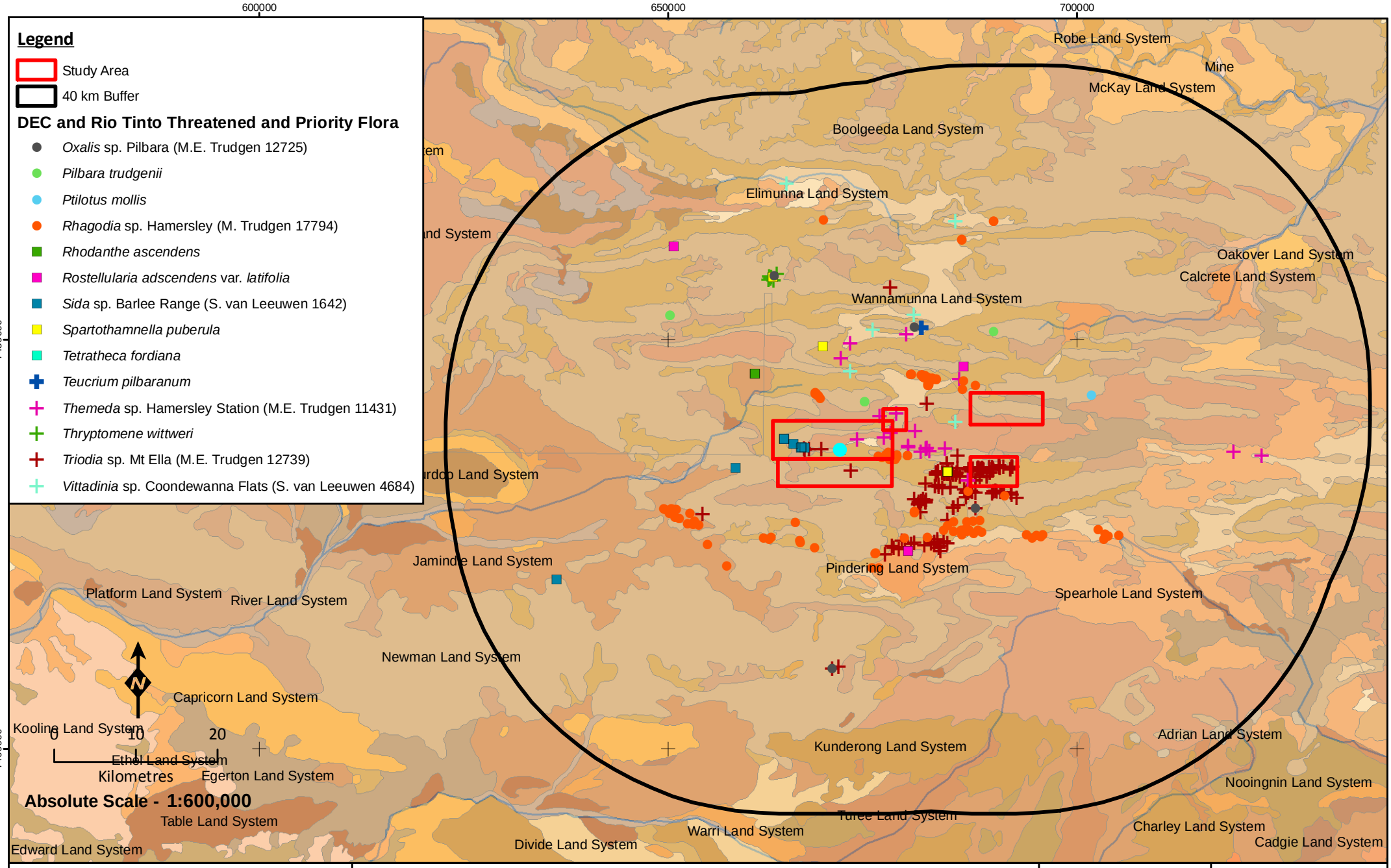
**Figure: 2.10**
**Project ID: 1457**

**Drawn: CP**
**Date: 19/09/2012**

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

Unique Map ID: CP170

**A4**

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

**Figure: 2.11**
**Project ID: 1457**

**Drawn: CP**
**Date: 19/09/2012**

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

Unique Map ID: CP172

**A4**

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# 3 SURVEY METHODOLOGY

## 3.1 GUIDING PRINCIPLES

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

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

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

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

## 3.2 DATABASE SEARCHES

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

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

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

## 3.3 VEGETATION AND FLORA ASSESSMENT

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

### 3.3.1 Survey Timing

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

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

The objectives of these surveys were to provide:

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

### 3.3.2 Quadrat-Based and Transect Sampling

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

Coordinates for all quadrats are detailed in Appendix A.

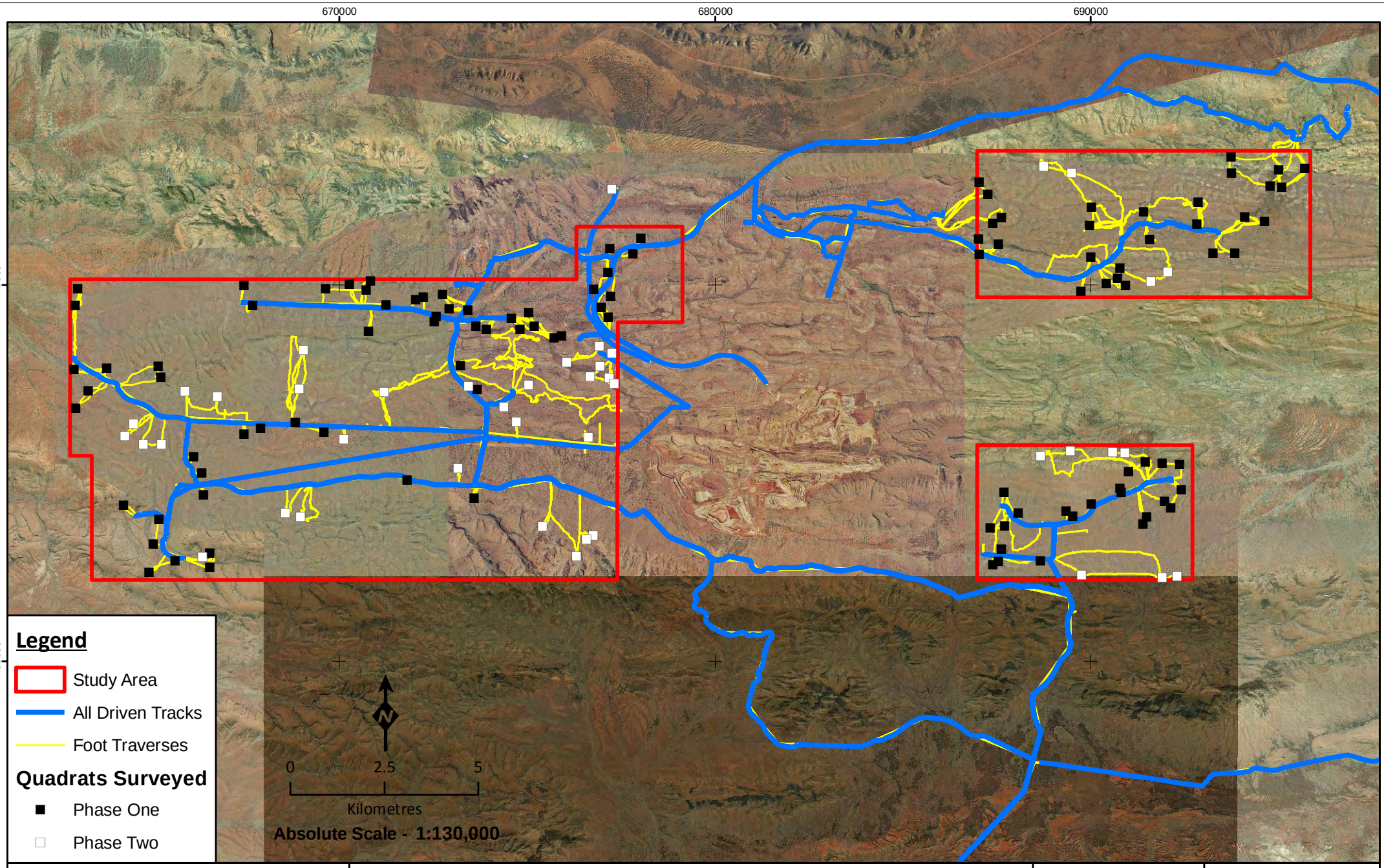
For each quadrat, the following was recorded:

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

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

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

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

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

**Figure: 3.1**
**Project ID: 1457**

**Drawn: CP**
**Date: 27/09/2012**

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

Unique Map ID: CP147

**A4**

### 3.3.3 Vegetation Condition

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

**Table 3.1 – Vegetation Condition Scale**

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

### 3.3.4 Vegetation Mapping

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

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

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

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# 4 FLORA RESULTS

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

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

**Table 4.1 – Diversity of the Flora of Survey Area**

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

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

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

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

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

### 4.1.1 Sampling Adequacy for the Study Area

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

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

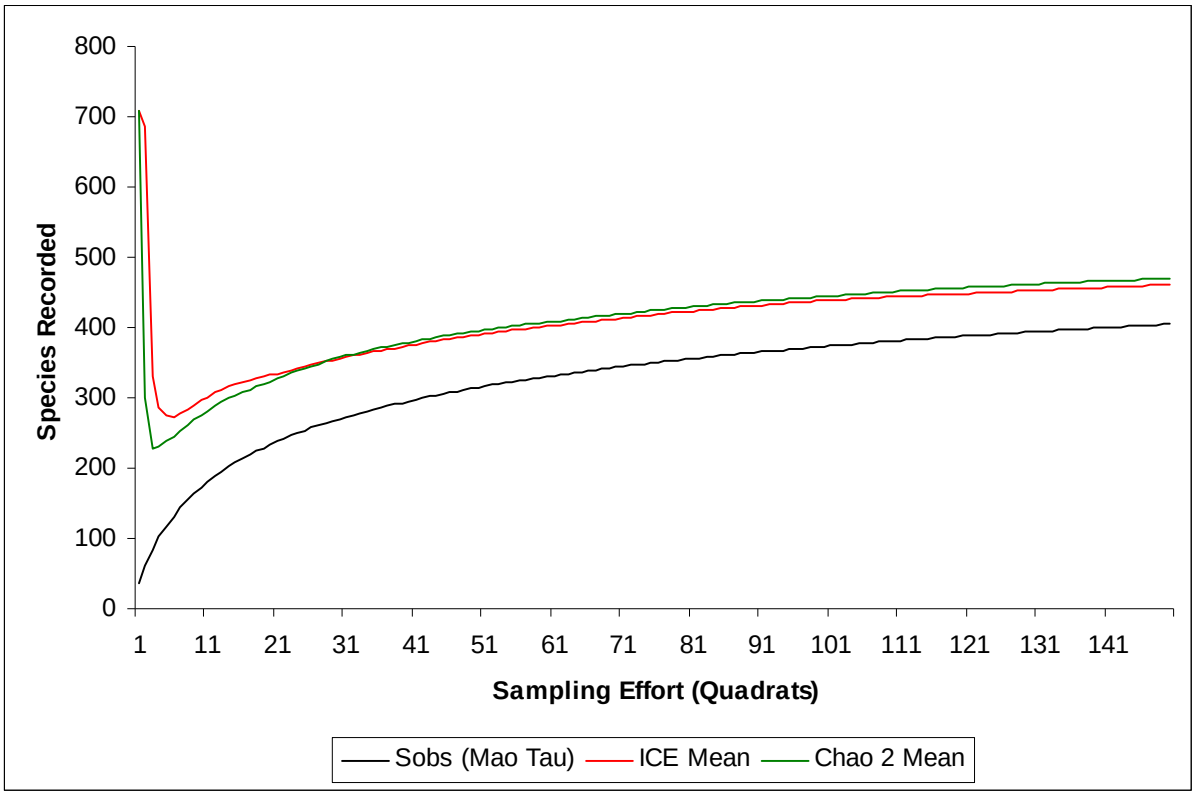



**Figure 4.1 – Average Randomised Species Accumulation Curve for Greater West Angelas**

## 4.2 FLORA OF CONSERVATION SIGNIFICANCE

### 4.2.1 EPCB Act

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

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

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

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

### 4.2.2 WC Act

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

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

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

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

### 4.2.3 Priority Flora

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

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

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

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

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

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

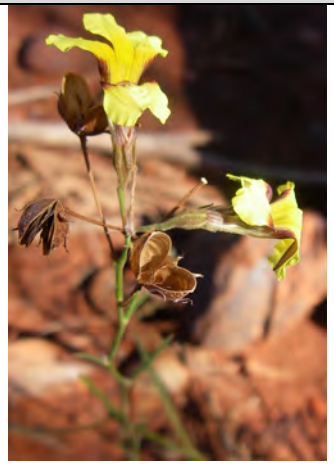
| Conservation Status | Taxon | Family | No. of records in Study Area | Habitat (WA Herbarium 2012) | Distribution | Flower Period | Picture |
|---|---|---|---|---|---|---|---|
| P1 | *Brachyscome* sp. Wanna Munna Flats (S. van Leeuwen 4662) PN<br><br>Erect annual herbaceous daisy with pinnatisect leaves and light purple flower heads. | Asteraceae | 2 locations<br>(2 plants) | Plain; deep clay loam with very fine buckshot gravel along with a clay crust on the surface | Tom Price, Newman | July, Sep |  <br>(*ecologia* 2012) |
| P1 | *Brunonia* sp. long hairs (D.E. Symon 2440) PN<br><br>Rosulate herb with long silvery hairs, especially at the base of the leaves and bright blue flowers in an aggregated head. | Goodeniaceae | 10 locations<br>(>20 plants) | Along creeklines and floodplains in clay or sandy clay | West Angelas, Newman | May |  <br>(*ecologia* 2012) |

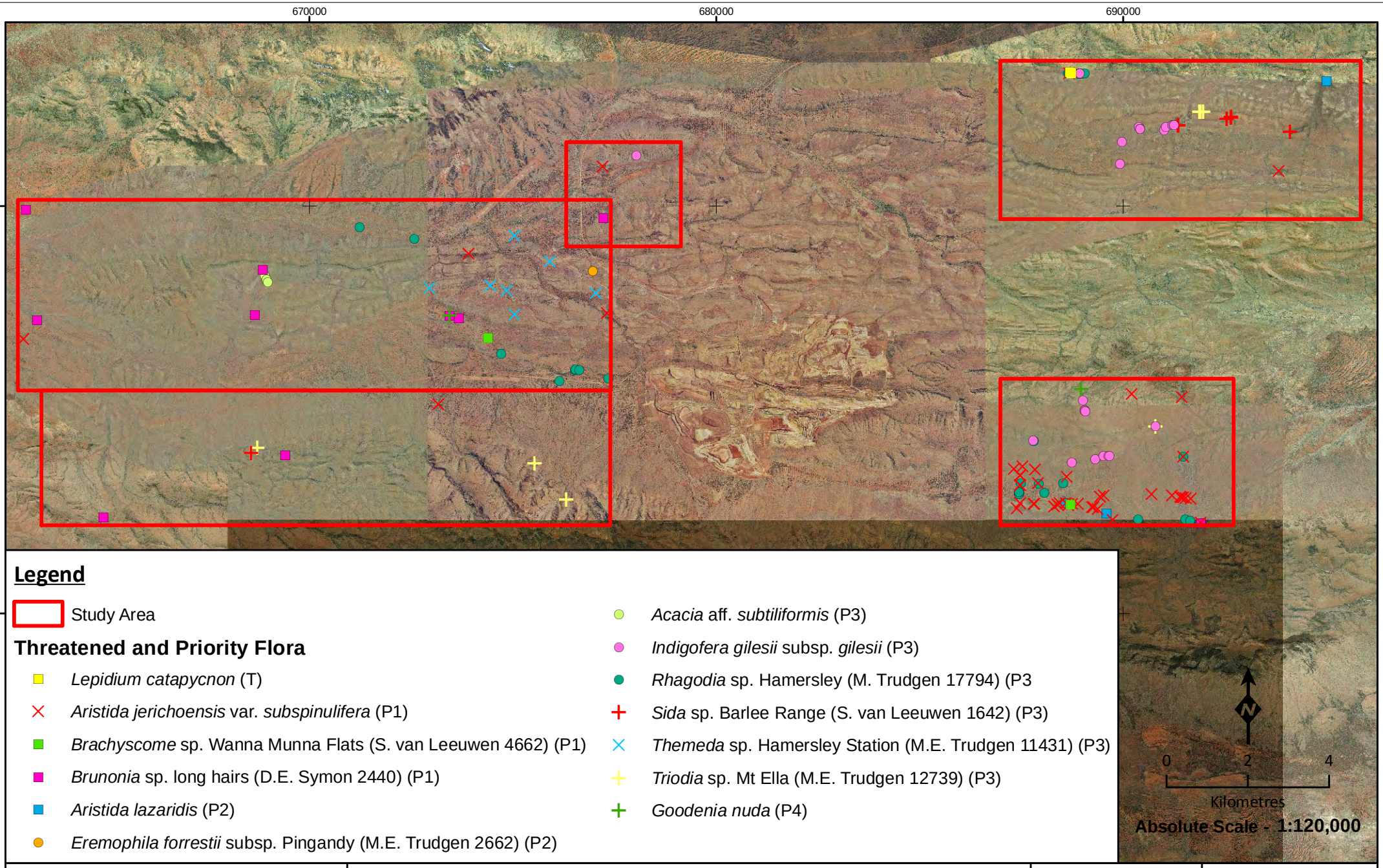
| Conservation Status | Taxon | Family | No. of records in Study Area | Habitat (WA Herbarium 2012) | Distribution | Flower Period | Picture |
|---|---|---|---|---|---|---|---|
| P2 | *Aristida lazaridis*<br><br>A tufted perennial grass. Leaf-blade surface scaberulous; rough on both sides. | Poaceae | 3 locations<br>(>23 plants) | Sand or loam | Karijini N.P., Queensland | Apr |  <br>(Western Australia Herbarium 2012) |
| P2 | *Eremophila forrestii* subsp. Pingandy (M.E. Trudgen 2662)<br><br>Shrub to 50 cm tall, compact tight bush. Flowers pale yellow-cream to pinky-yellow. | Scrophulariaceae | 1 location<br>(1 plant) | Flat terrain, low in landscape, base of broad valley, stony gibber plain above shallow drainage line, red clay-loam. | West Angela Hill, Karijini National Park, Turee Creek Homestead | Jun |  <br>(*ecologia* 2012) |

| Conservation Status | Taxon | Family | No. of records in Study Area | Habitat (WA Herbarium 2012) | Distribution | Flower Period | Picture |
|---|---|---|---|---|---|---|---|
| P3 | *Acacia* aff. *subtiliformis*<br><br>Erect, spindly, wispy, single-stemmed, glabrous shrubs, the upper branches scarred where phyllodes have fallen. | Fabaceae | 3 locations<br>(~250 plants) | On rocky calcrete plateaus | Hamersley Ranges, Hancock Range, Ophthalmia Range, Hope Down North, Marillana Stn | Jul, Aug |  <br>(*ecologia* 2012) |
| P3 | *Indigofera* sp. Gilesii (M.E. Trudgen 15869)<br><br>An open shrub, to 1.5 m high with purple-pink flowers. | Fabaceae | 24 locations<br>(>232 plants) | Pebbly loam amongst boulders & outcrops. Hills | Mt Ella, Newman, Rhodes Ridge, Coondewanna and West Angelas Hill | May or Aug |  <br>(*ecologia* 2012) |

| Conservation Status | Taxon | Family | No. of records in Study Area | Habitat (WA Herbarium 2012) | Distribution | Flower Period | Picture |
|---|---|---|---|---|---|---|---|
| P3 | *Rhagodia* sp. Hamersley (M. Trudgen 17794)<br><br>Small erect, open shrub or scrambler to 4 m high with green - cream flowers. | Chenopodiaceae | 31 locations<br>(>81 plants) | Gravely silt and sand in sheet-flood fans. Red brown silty clay loam / silty loam on undulating plains. | Tom Price, Paraburdoo, Brockman and Newman | May |  <br>(*ecologia* 2012) |
| P3 | *Sida* sp. Barlee Range (S. van Leeuwen 1642) PN<br><br>Rounded, densely woolly to velvety somewhat woody shrub, with small ovate ruminate leaves and yellow flowers. | Malvaceae | 8 locations<br>(>42 plants) | Skeletal red soils pockets. Steep slope. | Barlee Range, Turee Creek, Paraburdoo, Hamersley Range | Aug |  <br>(*ecologia* 2012) |

| Conservation Status | Taxon | Family | No. of records in Study Area | Habitat (WA Herbarium 2012) | Distribution | Flower Period | Picture |
|---|---|---|---|---|---|---|---|
| P3 | *Themeda* sp. Hamersley Station (M.E. Trudgen 11431) PN<br><br>A robust Kangaroo Grass, tall, with a bluish tinge to tussock. | Poaceae | 7 locations<br>(>3505 plants) | Red clay. Clay pan, grass plain | Karratha, Millstream, Hamersley Stn, West Angelas, Coondewanna Flats | Aug |  <br>(*ecologia* 2012) |
| P3 | *Triodia* sp. *Mt Ella (M.E. Trudgen 12739)*<br><br>A diffuse, loose, sprawling rather than rounded, hummock hard spinifex grass, leaves bright mid-green, shiny, very resinous with a distinctive resinous smell. | Poaceae | 8 locations<br>(>300 plants) | Rangeland. Hillside and hill top. Brown/red ironstone gravel | Yarraloola Stn, Yalleen Stn., Red Hill Stn., Mt Stuart Stn., Hamersley Range | - |  <br>(*ecologia* 2012) |

| Conservation Status | Taxon | Family | No. of records in Study Area | Habitat (WA Herbarium 2012) | Distribution | Flower Period | Picture |
|---|---|---|---|---|---|---|---|
| P4 | *Goodenia nuda*<br><br>An erect herb with yellow flowers with a maroon centre. | Goodeniaceae | 2 location<br>(2 plants) | Dry brown-red sand – loam occasionally in areas of recent burns. | Port Headland, Newman, Onslow, Paraburdoo and Tom Price | Apr to Aug |  <br>(*ecologia* 2011) |




## Legend

- Study Area

### Threatened and Priority Flora

- *Lepidium catapycnon* (T)
- *Aristida jerichoensis* var. *subspinulifera* (P1)
- *Brachyscome* sp. Wanna Munna Flats (S. van Leeuwen 4662) (P1)
- *Brunonia* sp. long hairs (D.E. Symon 2440) (P1)
- *Aristida lazaridis* (P2)
- *Eremophila forrestii* subsp. Pingandy (M.E. Trudgen 2662) (P2)
- *Acacia* aff. *subtiliformis* (P3)
- *Indigofera gilesii* subsp. *gilesii* (P3)
- *Rhagodia* sp. Hamersley (M. Trudgen 17794) (P3
- *Sida* sp. Barlee Range (S. van Leeuwen 1642) (P3)
- *Themeda* sp. Hamersley Station (M.E. Trudgen 11431) (P3)
- *Triodia* sp. Mt Ella (M.E. Trudgen 12739) (P3)
- *Goodenia nuda* (P4)

N

0 2 4

Kilometres

**Absolute Scale - 1:120,000**

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# Threatened and Priority Flora of the Greater West Angelas Study Area

**Figure: 4.2**
**Project ID: 1457**

**Drawn: CP**
**Date: 16/10/2012**

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

Unique Map ID: CP148

**A4**

### 4.2.4 Range Extensions Recorded in the Study Area

The extensions of the known range of distribution for flora recorded in the Study Area have been subdivided into three categories:

- Bioregional Extensions: the taxon has not been previously recorded in the IBRA Bioregion in which the Study Area is located;
- Range Extension: the records in this study are at least 100 km from the boundary of distribution based on lodged records; and
- Bridging Record: a record lying between widely separated populations.

Based on collection records lodged at the WA Herbarium (Western Australian Herbarium 1998-2013), records from the current survey include one bioregional extension, *Maireana lanosa*, although only 44 km north of the known population. Records of two taxa represent range extensions; *Corymbia zygophylla* and *Euphorbia schultzii* (Table 4.4). Threatened and Priority Flora Report Forms have been completed for these taxa ready for lodgement and can be found in Appendix F

One additional species, *Yakirra australiensis* var. *australiensis* has been determined to be a bridging record, as itscollection point was at least 250 km from any other known location.

**Table 4.4 – Collections in the Survey Area that Increase the Known Distribution of its Taxa**

| Taxon | Type of record | Notes | *ecologia* locations | WAHERB locations |
|---|---|---|---|---|
| *Maireana lanosa* | Bioregional Extension | 44 km N of known population<br>First record of the species in the Pilbara Bioregion | 1 | 28 |
| *Corymbia zygophylla* | Range Extension | 210 km S of northern population and 300 km E of western population in the Pilbara | 1 | 97 |
| *Euphorbia schultzii* | Range Extension | 102 km SE of known population | 2 | 50 |
| *Yakirra australiensis* var. *australiensis* | Bridging Record | 264 km SE of Pilbara population and 700 km W of eastern record | 1 | 9 |

## 4.3 INTRODUCED FLORA

### 4.3.1 Weeds of National Significance (WONS)

At a national level there are twenty introduced flora species listed as Weeds of National Significance (WONS). *The Commonwealth National Weeds Strategy: A Strategic Approach* to *Weed Problems* of *National Significance* (2012) describes broad goals and objectives to manage these species. Of these species, eight are currently recorded within the Pilbara (Mesquite, *Prosopis* spp.; Athel Pine, *Tamarix aphylla;* Common prickly pear, *Opuntia stricta; Parthenium hysterophorus; Prosopis glandulosa x velutina;* Mesquite, *Prosopis pallida;* Salvinia, *Salvinia molesta;* Athel tree, *Tamarix aphylla;* and Parkinsonia, *Parkinsonia aculeata*) but are not known from the Study Area.

No Weeds of National Significance were recorded in the Study Area.

### 4.3.2 Declared Plants

Weeds that are, or have the potential to become, pests to agriculture can be declared formally under the *Agriculture and Related Resources Protection Act 1976* (ARRP Act Department of Agriculture and Food 1976) as Declared Plants. Weeds listed under this Act are listed with Standard Control Codes that outline the requirements for their control. Five priority groupings exist (P1, P2, P3, P4 or P5) and more than one priority may be assigned to a weed species. Different priority levels apply to different municipal districts . Details of these codes are included in Appendix G. Landholders having Declared Plants on their property are obliged to control them at their own expense, and are encouraged to follow the standard control codes.

No Declared Plants were recorded by *ecologia* in the West Angelas Study Area.

### 4.3.3 Environmental Weeds

A third and much more extensive categorisation of weeds has been developed by the DEC, formerly the Department of Conservation and Land Management (CALM) in the Environmental Weed Strategy for Western Australia (Department of Conservation and Land Management 1999). Weed species considered to adversely affect the communities they invade are evaluated based on the degree of invasiveness, distribution and environmental impacts. Weeds listed as Environmental Weeds are ranked into four categories using the above criteria and the scoring system:

- High; a species which scores as yes to all three of the above criteria. A rating of high indicates a species that should be prioritised for control and/or research;
- Moderate; a species which scores yes for two of the above criteria. A rating of moderate indicates a species which should be monitored. Control or research should be directed to it if funds are available;
- Mild; a species which scores yes to one of the criteria. A mild rating indicates monitoring or control if appropriate; and
- Low; a species which does not score yes for any of the criteria. A low rating indicates a low requirement for monitoring.

The assessment has recently been expanded to include a number of other criteria, although no revision of the Environmental Rating has been published.

The following nine weed species were recorded within the Study Area:

- *Acetosa vesicaria;*
- *Bidens bipinnata*;
- *Cenchrus ciliaris*;
- *Cenchrus setiger;*
- *Flaveria trinervia*;
- *Malvastrum americanum*;
- *Portulaca oleracea*;
- *Sigesbeckia orientalis*; and
- *Vachellia farnesiana*.

The locations at which these species were recorded are listed in Appendix H and mapped in Figure 4.3. The characteristics and broad distributions of these species are summarised in Table 4.5 and Table 4.6.

**Table 4.5 – Environmental Status of Introduced Species Recorded in the Study Area**

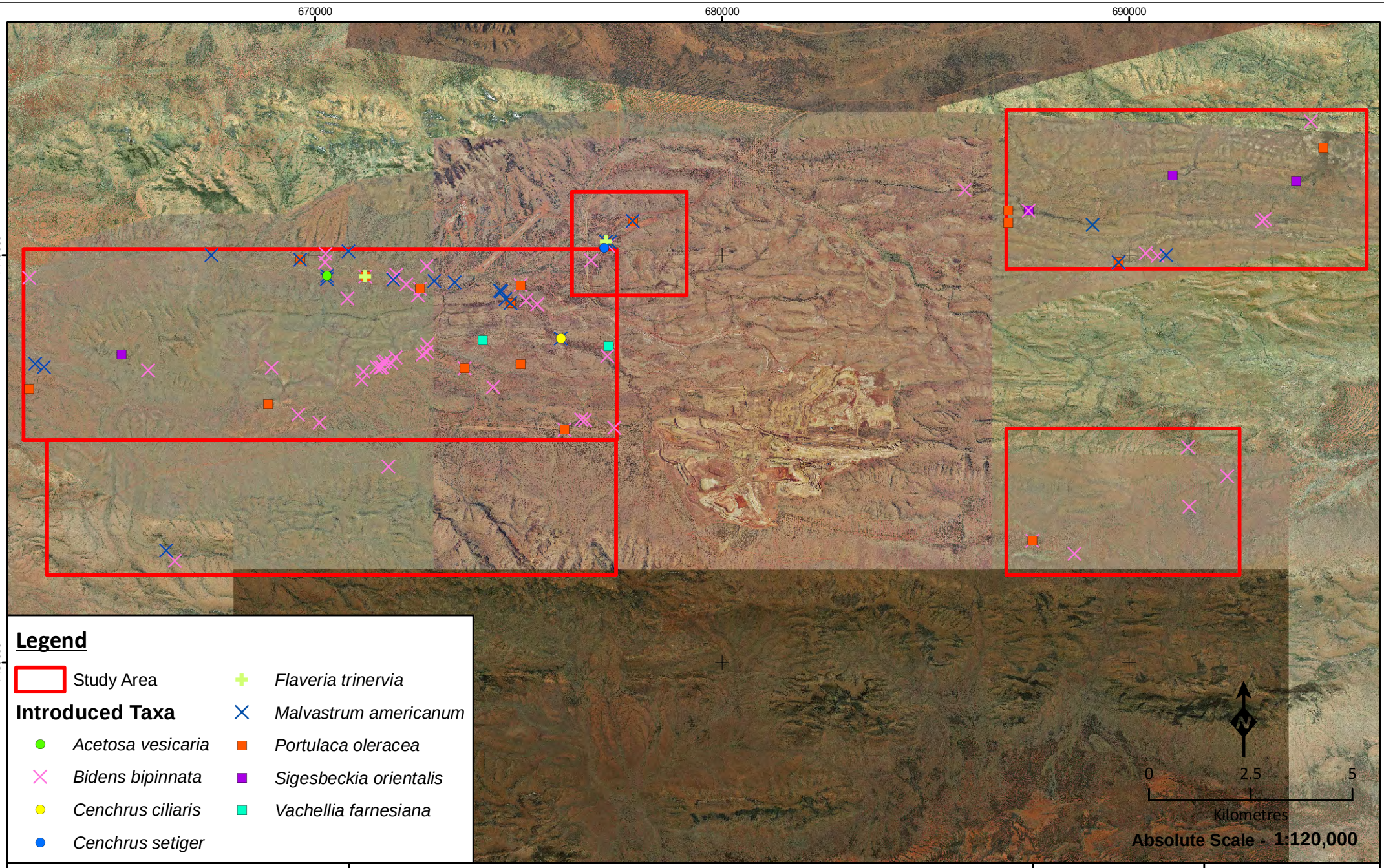
| Taxa | DEC Environmental Threat Assessment for the Pilbara Bioregion (DEC 2011) | | | | | | | | No. locations within Study Area |
|---|---|---|---|---|---|---|---|---|---|
| | Env. Rating | Current Distrib. | Abundance | Ecological Impact | Invasiveness | Feasibility of Control | General Trend | Status | |
| *Acetosa vesicaria* | Unrated | High | Common | High | Rapid | High | Increasing | Established | 1 |
| *Bidens bipinnata* | Unrated | High | - | Unknown | Rapid | Low | - | - | 72 |
| *Cenchrus ciliaris* | High | High | Abundant | High | Rapid | Low | Increasing | Established | 1 |
| *Cenchrus setiger* | High | High | Abundant | High | Rapid | Low | Increasing | Established | 1 |
| *Flaveria trinervia* | not listed | | | | | | | | 2 |
| *Malvastrum americanum* | Moderate | High | Abundant | High | Rapid | Low | Increasing | Established | 22 |
| *Portulaca oleracea* | Low | - | - | Low | - | - | - | - | 17 |
| *Sigesbeckia orientalis* | Moderate | Moderate | - | Unknown | Rapid-Moderate | Low | - | - | 4 |
| *Vachellia farnesiana* | High | High | Common | High | Rapid | Low | Stable | Established | 2 |

**Table 4.6 – Introduced Flora Recorded in the Study Area**

| Taxon | Description | Picture |
|---|---|---|
| *Acetosa vesicaria*<br><br>Polygonaceae<br><br>(ruby dock; rosy dock) | *Acetosa vesicaria* is an erect, stout, fleshy herb from 0.2 to 1 m high (Western Australian Herbarium 1998-2012) with broadly triangular leaves ad inconspicuous flowers (Hussey *et al*. 2007). Red or pink flowers can be seen from July to September (Western Australian Herbarium 1998-2012).<br><br>This weed is widely distributed in the Eremaean and South-west regions of Western Australia along roadsides and disturbed areas (Western Australian Herbarium 1998-2012).<br><br>Native to North Africa, Middle East and India (Hussey *et al*. 2007). |  <br>(*ecologia* 2012) |
| *Bidens bipinnata*<br><br>Asteraceae<br><br>(beggar's ticks) | *Bidens bipinnata* is an erect annual herb, 0.1 to 1.5 m high with yellow flowers from March to September (Western Australian Herbarium 1998-2012).<br><br>It grows on alluvium, clay, loam over sandstone, limestone, along rivers and creeks, coastal areas and rocky hillsides (Western Australian Herbarium 1998-2012).<br><br>*B*idens *bipinnata* is found worldwide and in Western Australia it is distributed in the Northern, Eremaean and South-West (Western Australian Herbarium 1998-2012). |  <br>(*ecologia* 2012) |
| *Cenchrus ciliaris*<br><br>Poaceae<br><br>(Buffel grass) | *Cenchrus ciliaris* is a tufted, often tussocking perennial grass up to 1 m high (Hussey *et al*. 2007). The inflorescence is cylindrical, with purple flowers produced from February to October (Western Australian Herbarium 1998-2012).<br><br>This species is found on white, red or brown sand, stony red loam or black cracking clay in the Northern, Eremaean and South-west regions of Western Australia (Western Australian Herbarium 1998-2012).<br><br>Apart from being widely distributed in Western Australia (Western Australian Herbarium 1998-2012), it is present in all States and territories of continental Australia (PlantNET 2013).<br><br>Native to Africa and India (Hussey *et al*. 2007). |  <br>(*ecologia* 2012) |

| Taxon | Description | Picture |
|---|---|---|
| *Cenchrus setiger*<br><br>Poaceae<br><br>(birdwood grass) | *Cenchrus setiger* is a tufted perennial up to 0.8 m high with a compact, green spike-like inflorescence up to 20 cm long (Hussey *et al*. 2007). Flowers are cream and purple, produced from April to May (Western Australian Herbarium 1998-2012).<br><br>The distribution of this species ranges from the Kimberley to Geraldton (Hussey *et al*. 2007).<br><br>It is native to Africa and India, and was introduced as a fodder plant in pastoral areas but is now a serious weed (Hussey *et al*. 2007). |  <br>(*ecologia* 2012) |
| *Flaveria trinervia*<br><br>Asteraceae<br><br>(Speedy weed) | *Flaveria trinervia* is a herb with yellow flowered clustered at the top and with finely serrated leaves.<br><br>It occurs in disturbed areas and waterways, and can often be found under the shade of other trees or shrubs. |  <br>(*Ecologia* 2012) |
| *Malvastrum americanum*<br><br>Malvaceae | *Malvastrum americanum* is an erect perennial herb or shrub from 0.5 to 1.3 m high (Western Australian Herbarium 1998-2012). The flowers are yellow to orange in a dense terminal spike (Hussey *et al*. 2007), open from April to July (Western Australian Herbarium 1998-2012).<br><br>It occurs in various soil types, including sands, clays, limestone and calcrete and can be found along drainage lines, floodplains, stony ridges and hillsides (Western Australian Herbarium 1998-2012). Distributed in the Northern and Eremaean regions of Western Australia (Western Australian Herbarium 1998-2012). |  <br>(*Ecologia* 2012) |
| *Portulaca oleracea*<br><br>Portulacaceae<br><br>(pig weed, purslane) | *Portulaca oleracea* is a succulent, prostrate to decumbent annual, herb up to 20 cm high (Western Australian Herbarium 1998-2012). Under water stress the whole plant becomes reddish (Hussey *et al*. 2007). It flowers between April and May and the petals are yellow (Western Australian Herbarium 1998-2012).<br><br>This species occurs in clay loam and sands and is often observed in disturbed sites (Western Australian Herbarium 1998-2012). It is a common and widespread weed of horticulture, paddocks and gardens (Hussey *et al*. 2007). |  <br>(*Ecologia* 2012) |

| Taxon | Description | Picture |
|---|---|---|
| | It is distributed widely in Western Australia, in the Northern, Eremaean and South-west (Western Australian Herbarium 1998-2012). | |
| *Sigesbeckia orientalis*<br><br>Asteraceae<br><br>(Indian weed) | *Sigesbeckia orientalis* is an erect slender annual herb up to 1 m high (Western Australian Herbarium 1998-2012).<br><br>It occurs on loamy soils over limestone or granite and can be found in rock gullies, limestone ranges or creek beds (Western Australian Herbarium 1998-2012).<br><br>*Sigesbeckia orientalis* is a cosmopolitan weed found in the Pilbara, and in forested areas between Perth and Albany (Hussey *et al.* 2007). |  <br>(Western Australian Herbarium 1998-2012) |
| *Vachellia farnesiana*<br><br>Fabaceae<br><br>(mimosa bush) | *Vachellia farnesiana* is an erect, spreading, thicket-forming, thorny tree or shrub up to 4 m high (Western Australian Herbarium 1998-2012). It has dark grey bark and pinnate green leaves (Western Australian Herbarium 1998-2012). Its flowers are yellow and open from June to August (Western Australian Herbarium 1998-2012).<br><br>This species occurs in various types of soil in disturbed sites in low-lying areas, river or creek banks in the Kimberley and Eremaean regions of Western Australia and also North of Perth (Western Australian Herbarium 1998-2012). |  <br>(*ecologia* 2012) |




ecologia ENVIRONMENT

# Introduced Flora of the Greater West Angelas Study Area

**Figure: 4.3**
**Project ID: 1457**

**Drawn: CP**
**Date: 16/10/2012**

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

Unique Map ID: CP149

**A4**

# 5 VEGETATION

## 5.1 VEGETATION CONDITION

The Study Area is not bound by, nor does it form part of any pastoral lease in the area. Exploration and mining leases owned by RT encompass 100% of the Study Area, which is subject to little grazing pressure from cattle or other livestock. Recorded evidence of grazing, scats and animal tracks from introduced species was minimal and this is reflected in the assessment of vegetation condition in surveyed quadrats, with 51% and 36% assessed as being in excellent or very good condition, respectively. The remaining quadrats were recorded as good (11%) or poor (2%). None were recorded to be in very poor condition. The disturbance most commonly observed was the presence of weed species, usually *Bidens bipinnata*, with a small number of areas subject to disturbance from previous exploration activities. Figure 5.1 details the condition rankings of all quadrats assessed within the Study Area. The majority of quadrats ranked as in good or poor condition are located within the drainage systems where seeds can be dispersed by water flow and upstream impacts from cattle grazing can be carried downstream.

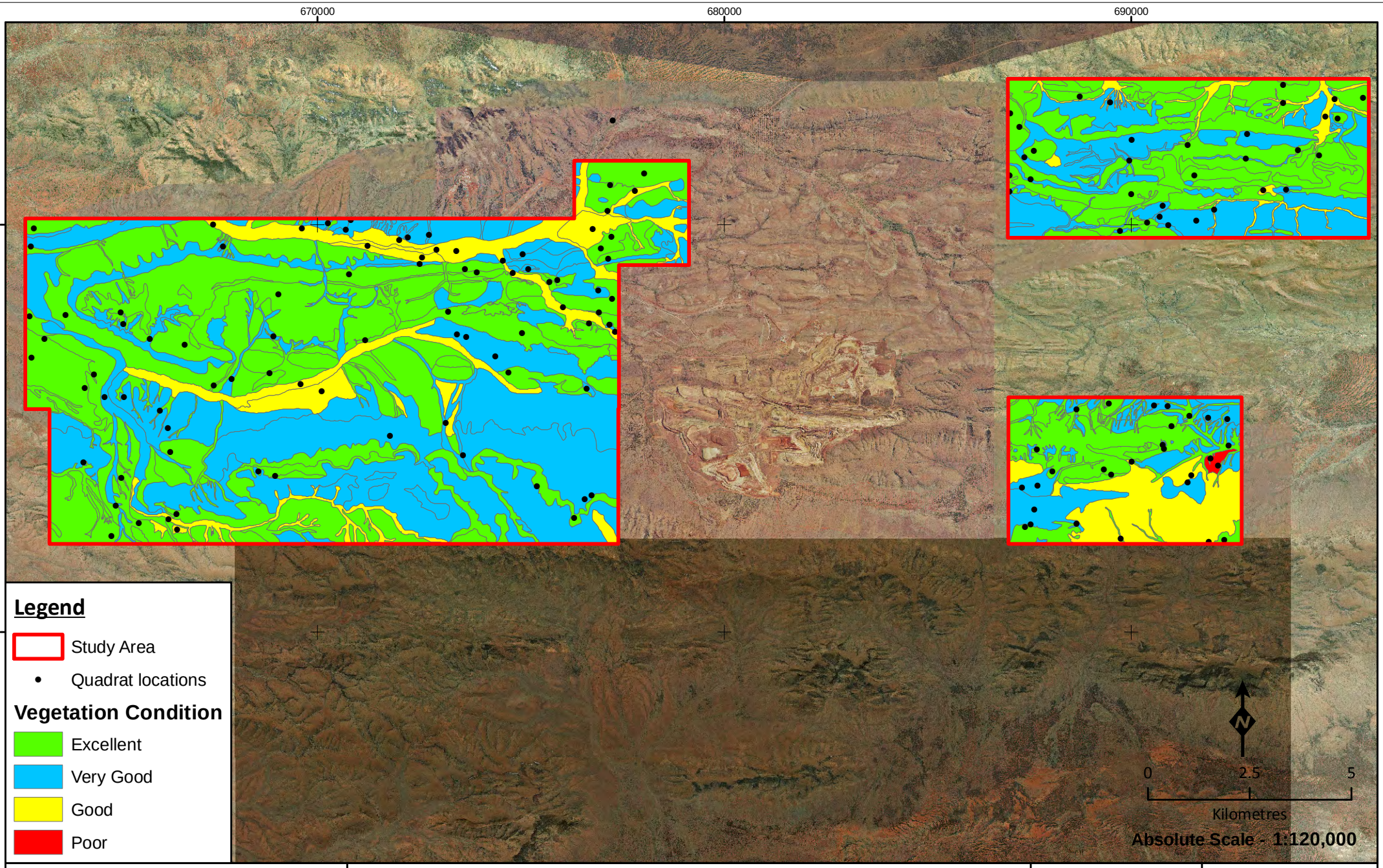
## 5.2 FIRE HISTORY OF THE STUDY AREA

The majority of the Study Area has not been recently burnt, with 50% of quadrats assessed as burnt more than 5 years ago or with no evidence of fire and 44% burnt 2-5 years ago. The pattern of burning appears sporadic and localised (Figure 5.2), which is typical of fires arising during the early wet season from lightning strikes that are extinguished relatively rapidly, rather than larger scale fires that burn an extensive area before being extinguished.

## 5.3 VEGETATION COMMUNITIES

Twenty two vegetation communities were described to association level (NVIS level V) and delineated within the Study Area, the characteristics of which are summarised in Table 5.1. The distribution of each vegetation unit is mapped in Figure 5.3 to 5.18 and the relative similarity of quadrats as determined by multivariate analysis is detailed in Figure 5.21. The structure and floristic composition of each quadrat is detailed in Appendix B.

The cluster analysis used in this study is based on both species composition and abundance. The resulting groups are in many cases based on the *Acacia, Senna* and *Triodia* species, which are commonly dominant taxa. In some cases, however, the vegetation units were also characterised by indicator species; i.e. taxa which are not dominant, but are totally or partially restricted to that particular vegetation unit.

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# Vegetation Condition of the Greater West Angelas Study Area

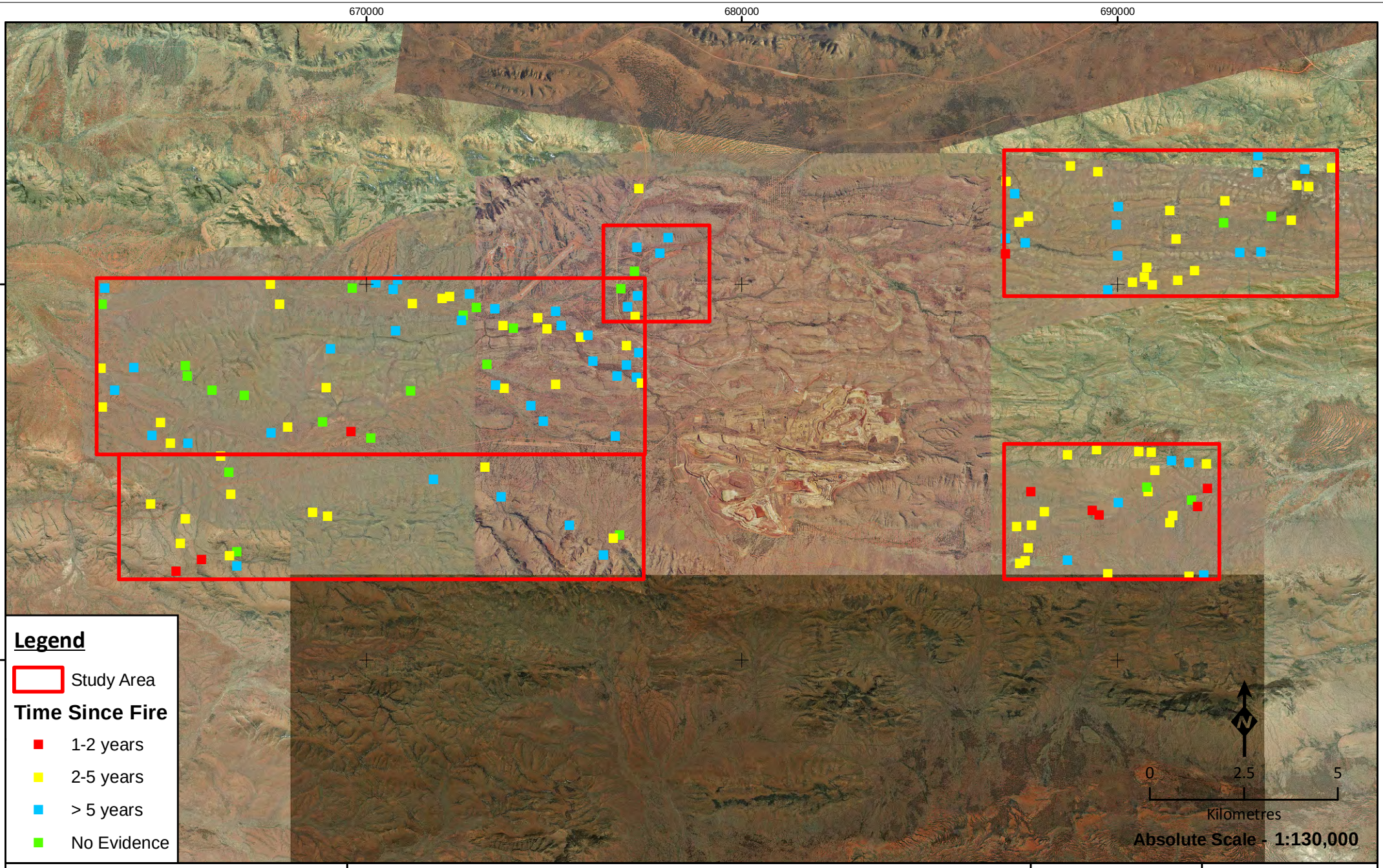
**Figure: 5.1**
**Project ID: 1457**

**Drawn: CP**
**Date: 27/09/2012**

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

Unique Map ID: CP146

**A4**

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# Fire History of the Greater West Angelas Study Area

**Figure: 5.2**
**Project ID: 1457**

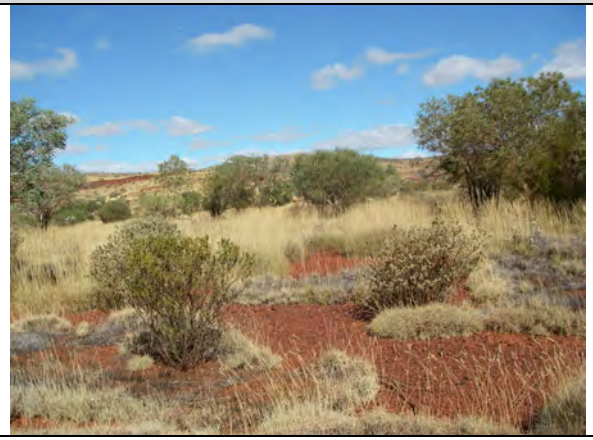
**Drawn: CP**
**Date: 27/09/2012**

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

Unique Map ID: CP145

**A4**

**Table 5.1 – Vegetation Units of West Angelas.**

| Vegetation unit mapping code | Quadrats | Vegetation description (NVIS Level V) | Associated species | Area km$^2$ (% of Study Area) | Photograph |
|---|---|---|---|---|---|
| **Gravely Plains** | | | | | |
| *AaTb*<br><br>*Acacia* open woodland over *Triodia* open hummock grassland | 14<br>16<br>28<br>75<br>107<br>109<br>114<br>121 | *Acacia aptaneura* and *A. pruinocarpa* open woodland over *A. bivenosa* isolated shrubs *Triodia basedowii* and *T. pungens* open hummock grassland.<br><br>Average species richness = 26.5 ± 1.9<br><br>Sample size = 8 | *Acacia prionocarpa*<br>*Triodia basedowii*<br>*Triodia pungens*<br>*Acacia aptaneura*<br>*Acacia bivenosa*<br>*Aristida contorta*<br>*Dysphania kalpari*<br>*Ptilotus calostachyus*<br>*Enneapogon polyphyllus*<br>*Eragrostis eriopoda*<br>*Eremophila forrestii* subsp. *forrestii*<br>*Senna glutinosa* subsp. *glutinosa* | 1512.6 ha<br><br>(8.6%) |  |
| *SggAbTp*<br><br>*Senna* and *Acacia* open shrubland over *Triodia* hummock grassland | 6<br>8<br>23<br>26<br>34<br>92<br>98<br>100<br>102 | *Acacia pruinocarpa* and *Eucalyptus leucophloia* subsp. *leucophloia* or *Corymbia hamersleyana* isolated trees over *Senna glutinosa* subsp. *glutinosa, Acacia bivenosa* and *Gossypium robinsonii* open shrubland over *Triodia pungens* hummock grassland.<br><br>Average species richness = 38.0 ± 5.0<br><br>Sample size = 9 | *Senna glutinosa* subsp. *glutinosa*<br>*Acacia pruinocarpa*<br>*Triodia pungens*<br>*Acacia bivenosa*<br>*Gossypium robinsonii*<br>*Ptilotus obovatus*<br>*Indigofera monophylla*<br>*Themeda triandra*<br>*Ptilotus rotundifolius*<br>*Evolvulus alsinoides* var. *villisocalyx*<br>*Tribulus suberosus*<br>*Eucalyptus leucophloia* subsp. *leucophloia*<br>*Acacia aptaneura*<br>*Corymbia hamersleyana* | 1539.18 ha<br><br>(8.75%) |  |

| Vegetation unit mapping code | Quadrats | Vegetation description (NVIS Level V) | Associated species | Area km$^2$ (% of Study Area) | Photograph |
|---|---|---|---|---|---|
| **Gullies** | | | | | |
| *AaPoTp*<br><br>*Acacia* open woodland over *Ptilotus* isolated shrubs over *Triodia* open tussock grassland | 25<br>33<br>72<br>74<br>129<br>148 | *Acacia aptaneura* open woodland over *Ptilotus obovatus* isolated shrubs over *Themeda triandra* and *Eriachne mucronata* open tussock grassland.<br><br>Average species richness = 39.2 ± 3.0<br><br>Sample size = 6 | *Eriachne mucronata*<br>*Ptilotus obovatus*<br>*Acacia aptaneura*<br>*Trichodesma zeylanicum*<br>*Triodia pungens*<br>*Themeda triandra*<br>*Gomphrena cunninghamii*<br>*Cymbopogon ambiguus*<br>*Dysphania rhadinostachya* subsp. *rhadinostachya*<br>*Pterocaulon sphaecelatum*<br>*Dodonaea pachyneura^*<br>*Ficus brachypoda^*<br>*Cyperus cunninghamii* subsp. *cunninghamii^* | 319.01 ha<br><br>(1.81%) |  |
| **Rocky Footslopes/Rises** | | | | | |
| *AaTssp*<br><br>*Acacia* open woodland over *Triodia* open hummock grassland | 42<br>59<br>60<br>79<br>82<br>90<br>131<br>155 | *Acacia aptaneura* and *A. pruinocarpa* open woodland over *A. tetragonophylla, Senna glutinosa* subsp. *glutinosa* and *S. artemisioides* subsp. *oligophylla* isolated shrubs over *Triodia wiseana* and *T. pungens* open hummock grassland.<br><br>Average species richness = 39.0 ± 3.2<br><br>Sample size = 8 | *Acacia aptaneura*<br>*Acacia pruinocarpa*<br>*Enneapogon polyphyllus*<br>*Senna glutinosa* subsp. *Glutinosa*<br>*Acacia tetragonophylla*<br>*Duperreya commixta*<br>*Ptilotus helipteroides*<br>*Rhagodia eremaea*<br>*Triodia wiseana*<br>*Triodia pungens*<br>*Senna artemisioides* subsp. *oligophylla*<br>*Aristida contorta*<br>*Acacia bivenosa*<br>*Bidens bipinnata* | 927.28 ha<br><br>(5.27%) |  |

| Vegetation unit mapping code | Quadrats | Vegetation description (NVIS Level V) | Associated species | Area km$^2$ (% of Study Area) | Photograph |
|---|---|---|---|---|---|
| **Rocky Hilltops** | | | | | |
| *EllSggTw*<br><br>*Eucalyptus* open woodland over *Senna* open shrubland over *Triodia* open hummock grassland | 2<br>5<br>35<br>57<br>133<br>156 | *Eucalyptus leucophloia* subsp. *leucophloia* and *Acacia aptaneura* open woodland over *Senna glutinosa* subsp. *glutinosa* and *S. artemisioides* subsp. *oligophylla* open shrubland over *Triodia wiseana* or *T. pungens* open hummock grassland.<br><br>Average species richness = 23.7 ± 2.7<br><br>Sample size = 6 | *Senna glutinosa* subsp. *glutinosa*<br>*Senna artemisioides* subsp. *oligophylla*<br>*Acacia bivenosa*<br>*Acacia inaequilatera*<br>*Ptilotus rotundifolius*<br>*Acacia tetragonophylla*<br>*Triodia wiseana*<br>*Triodia pungens*<br>*Eucalyptus leucophloia* subsp. *leucophloia*<br>*Acacia aptaneura*<br>*Acacia pruinocarpa*<br>*Hakea chordophylla* | 1227.4 ha<br><br>(6.98%) |  |
| *EllAmTssp*<br><br>*Eucalyptus* open woodland over *Senna* open shrubland over *Triodia* open hummock grassland | 20<br>40<br>56<br>105<br>106<br>110<br>113<br>127<br>140<br>142<br>147<br>149 | *Eucalyptus leucophloia* subsp. *leucophloia* and *E. gamophylla* open woodland over *Acacia maitlandii, A. hamersleyensis, Keraudrenia velutina* and *Senna glutinosa* subsp. *glutinosa* open shrubland over *Triodia wiseana* and/or *T. pungens* and/or *T. basedowii* open hummock grassland.<br><br>Average species richness = 27.4 ± 1.1<br><br>Sample size = 12 | *Acacia maitlandii*<br>*Senna glutinosa* subsp. *glutinosa*<br>*Eucalyptus leucophloia* subsp. *leucophloia*<br>*Hakea chordophylla*<br>*Goodenia triodiophyla*<br>*Triodia wiseana*<br>*Triodia basedowii*<br>*Triodia pungens*<br>*Acacia hamersleyensis*<br>*Gompholobium oreophilum*<br>*Keraudrenia velutinea*<br>*Corchorus lasiocarpus*<br>*Acacia pyrifolia* var. *pyrifolia*<br>*Eucalyptus gamophylla* | 1215.97 ha<br><br>(6.91%) |  |

| Vegetation unit mapping code | Quadrats | Vegetation description (NVIS Level V) | Associated species | Area km$^2$ (% of Study Area) | Photograph |
|---|---|---|---|---|---|
| *AmTw*<br><br>*Acacia* sparse shrubland over *Triodia* hummock grassland | 37<br>38<br>136<br>153 | *Eucalyptus leucophloia* subsp. *leucophloia* isolated trees over *Acacia maitlandii* sparse shrubland over *Triodia wiseana* and *T. longiceps* hummock grassland.<br><br>Average species richness = 17.3 ± 3.8<br><br>Sample size = 4 | *Triodia wiseana*<br>*Acacia maitlandii*<br>*Acacia bivenosa*<br>*Eucalyptus leucophloia* subsp. *leucophloia*<br>*Petalostylis labicheoides*<br>*Ptilotus calostachyus*<br>*Themeda triandra*<br>*Triodia longiceps*<br>*Acacia pyrifolia* subsp. *pyrifolia*<br>*Ptilotus nobilis* subsp. *nobilis*<br>*Senna artemisioides* subsp. *oligophylla*<br>*Melaleuca eleuterostachya*^ | 108.7 ha<br><br>(0.62%) |  |
| *EllSggTp*<br><br>*Eucalyptus* open woodland over *Senna* open shrubland over *Triodia* open hummock grassland | 3<br>11<br>24<br>27<br>103<br>139<br>151<br>152 | *Eucalyptus leucophloia* subsp. *leucophloia* and *Acacia marramambra* open woodland over *Senna glutinosa* subsp. *glutinosa* open shrubland over *Triodia pungens* open hummock grassland.<br><br>Average species richness = 36.4 ± 3.0<br><br>Sample size = 8 | *Senna glutinosa* subsp. *glutinosa*<br>*Eucalyptus leucophloia* subsp. *leucophloia*<br>*Aristida contorta*<br>*Triodia pungens*<br>*Acacia pruinocarpa*<br>*Eriachne mucronata*<br>*Eremophila latrobei* subsp. *latrobei*<br>*Ptilotus nobilis* subsp. *nobilis*<br>*Enneapogon polyphyllus*<br>*Ptilotus calostachyus*<br>*Solanum lasiophyllum*<br>*Acacia marramamba*<br>*Acacia aptaneura* | 2491.87 ha<br><br>(14.16%) |  |

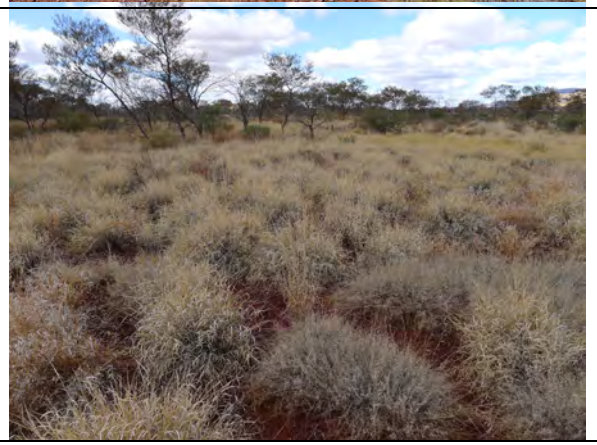
| Vegetation unit mapping code | Quadrats | Vegetation description (NVIS Level V) | Associated species | Area km$^2$ (% of Study Area) | Photograph |
|---|---|---|---|---|---|
| *SggIrTw*<br><br>*Senna* shrubland over *Triodia* hummock grassland | 132<br>134<br>143<br>144<br>160 | *Acacia inaequilatera* isolated trees over *Senna glutinosa* subsp *glutinosa* and *Indigofera rugosa* open shrubland over *Triodia wiseana* hummock grassland.<br><br>Average species richness = 27.0 ± 3.6<br><br>Sample size = 5 | *Triodia wiseana*<br>*Senna glutinosa* subsp. *glutinosa*<br>*Acacia inaequilatera*<br>*Indigofera rugosa^*<br>*Themeda triandra*<br>*Senna artemisioides* subsp. *oligophylla*<br>*Acacia dictyophleba*<br>*Coryotheca micrantha^*<br>*Enneapogon caerulescens*<br>*Goodenia muelleriana*<br>*Trichodesma zeylanicum* | 1045.87 ha<br><br>(5.94%) |  |
| **Rocky Midslope** | | | | | |
| *AaEffTp*<br><br>*Acacia* open woodland over *Eremophila* sparse shrubland and *Triodia* sparse hummock grassland | 85<br>65 | *Acacia aptaneura* and *A. pruinocarpa* open woodland over sparse *Eremophila fraseri* subsp. *fraseri* and *Acacia marramamba* sparse shrubland over *Triodia pungens* sparse hummock grassland.<br><br>Average species richness = 38.0 ± 5.0<br><br>Sample size = 2 | *Acacia aptaneura*<br>*Acacia pruinocarpa*<br>*Triodia pungens*<br>*Acacia marramamba*<br>*Eremophila fraseri* subsp. *fraseri*<br>*Acacia bivenosa*<br>*Aristida contorta*<br>*Codonocarpus cotinifolius*<br>*Duperreya commixta*<br>*Evolvulus alsinoides* var. *villosicalyx*<br>*Exocarpos sparteus*<br>*Grevillea berryana*<br>*Hibiscus burtonii* | 141.54 ha<br><br>(0.8%) |  |

| Vegetation unit mapping code | Quadrats | Vegetation description (NVIS Level V) | Associated species | Area km$^2$ (% of Study Area) | Photograph |
|---|---|---|---|---|---|
| *Tp*<br><br>*Triodia* hummock grassland | 4<br>15<br>22<br>36 | *Eucalyptus leucophloia* subsp. *leucophloia* and *Acacia pruinocarpa* isolated trees over *Senna glutinosa* subsp. *glutinosa, A. bivenosa* and *Ptilotus rotundifolius* isolated shrubs over *Triodia pungens* or *T. basedowii* or *T.* sp. Mt Ella hummock grassland.<br>Average species richness = 16.8 ± 1.5<br>Sample size = 4 | *Senna glutinosa* subsp. *glutinosa*<br>*Acacia bivenosa*<br>*Acacia pruinocarpa*<br>*Ptilotus rotundifolius*<br>*Eriachne mucronata*<br>*Eucalyptus leucophloia* subsp. *leucophloia*<br>*Ischaemum albovillosum*<br>*Triodia pungens*<br>*Cymbopogon ambiguus*<br>*Eremophila fraseri* subsp. *fraseri*<br>*Paspalidium clementii*<br>*Triodia* sp. Mt Ella<br>*Templetonia egena*^<br>*Senna sericea*^ | 975.86 ha<br><br>(5.55%) |  |
| *ApTssp*<br><br>*Acacia* open woodland over *Triodia* open hummock grassland | 30<br>58<br>125<br>128 | *Acacia pruinocarpa* and *Eucalyptus leucophloia* subsp. *leucophloia* open woodland over *Senna glutinosa* subsp. *glutinosa* and *A. maitlandii* isolated shrubs over *Triodia basedowii* or *T. pungens* or *T. wiseana* open hummock grassland.<br>Average species richness = 15.8 ± 5.7<br>Sample size = 4 | *Senna glutinosa* subsp. *glutinosa*<br>*Acacia pruinocarpa*<br>*Eucalyptus leucophloia* subsp. *leucophloia*<br>*Acacia maitlandii*<br>*Senna ferraria*<br>*Triodia pungens*<br>*Triodia basedowii*<br>*Indigofera monophylla*<br>*Acacia pyrifolia* var. *pyrifolia*<br>*Acacia sibirica*<br>*Corymbia deserticola* subsp. *deserticola* | 292.18 ha<br><br>(1.66%) |  |

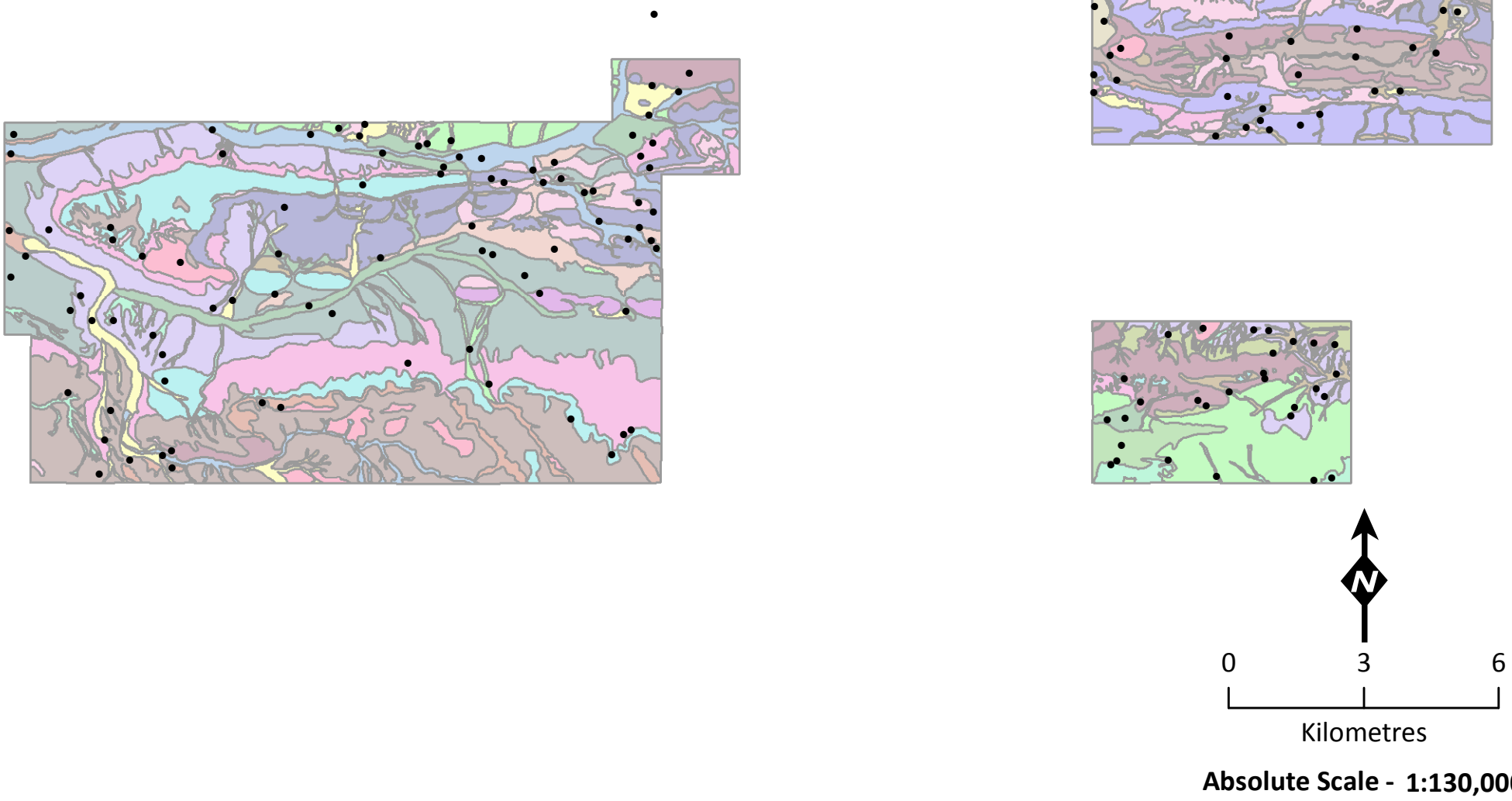
| Vegetation unit mapping code | Quadrats | Vegetation description (NVIS Level V) | Associated species | Area km$^2$ (% of Study Area) | Photograph |
|---|---|---|---|---|---|
| *SggTp*<br><br>*Senna* sparse shrubland over *Triodia* open hummock grassland | 111<br>112<br>120<br>124<br>126<br>146 | *Eucalyptus leucophloia* subsp. *leucophloia* and *Corymbia hamersleyana* isolated trees over *Senna glutinosa* subsp. *glutinosa* and *Acacia maitlandii* sparse shrubland over *Triodia pungens* open hummock grassland.<br><br>Average species richness = 34.2 ± 3.8<br><br>Sample size = 6 | *Senna glutinosa* subsp. *glutinosa*<br>*Corymbia hamersleyana*<br>*Themeda triandra*<br>*Acacia maitlandii*<br>*Dodonaea lanceolata* var. *lanceolata*^<br>*Jasminum didymum* subsp. *lineare*<br>*Triodia pungens*<br>*Eucalyptus leucophloia* subsp. *leucophloia*<br>*Androcalva luteiflora*<br>*Gossypium robinsonii*<br>*Indigofera monophylla*<br>*Senna ferraria* | 210.6 ha<br><br>(1.2%) |  |
| **Sandy Floodplains/Dry Rivers** | | | | | |
| *AaPoTt*<br><br>*Acacia* open woodland over *Ptilotus* sparse shrubland over *Themeda* open tussock grassland | 7<br>31<br>43<br>76<br>84<br>87<br>96<br>97<br>104<br>130<br>141<br>201 | *Acacia aptaneura* open woodland over *Ptilotus obovatus* sparse shrubland over *Themeda triandra* open tussock grassland.<br><br>Average species richness = 50.1 ± 2.9<br><br>Sample size = 12 | *Ptilotus obovatus*<br>*Salsola australis*<br>*Pterocaulon sphacelatum*<br>*Cleome viscose*<br>*Bidens bipinnata*<br>*Enneapogon polyphyllus*<br>*Evolvulus alsinoides* var. *villisocalyx*<br>*Malvastrum americanum*<br>*Ptilotus nobilis* subsp. *nobilis*<br>*Acacia aptaneura*<br>*Themeda triandra*<br>*Rhagodia eremaea*<br>*Eucalyptus victrix*^<br>*Triraphis mollis*^<br>*Corchorus tridens*^<br>*Amaranthus mitchellii*^ | 706.06 ha<br><br>(4.01%) |  |

| Vegetation unit mapping code | Quadrats | Vegetation description (NVIS Level V) | Associated species | Area km$^2$ (% of Study Area) | Photograph |
|---|---|---|---|---|---|
| *AaTt*<br><br>*Acacia* woodland over *Themeda* open tussock grassland | 55<br>99<br>123<br>135<br>137<br>138<br>145 | *Acacia aptaneura* and *Eucalyptus xerothermica* woodland over *Ptilotus obovatus* isolated shrubs over *Themeda triandra* open tussock grassland<br><br>Average species richness = 44.6 ± 2.3<br><br>Sample size = 7 | *Themeda triandra*<br>*Aristida contorta*<br>*Pterocaulon sphacelatum*<br>*Enneapogon polyphyllus*<br>*Ptilotus nobilis* subsp. *nobilis*<br>*Cleome viscose*<br>*Duperreya commixta*<br>*Evolvulus alsinoides* var. *villisocalyx*<br>*Acacia aptaneura*<br>*Eucalyptus xerothermica*<br>*Ptilotus obovatus*<br>*Capparis lasiantha*<br>*Eucalyptus trivalva*^ | 391.54 ha<br><br>(2.23%) |  |
| **Floodplains/Drainage lines** | | | | | |
| *AaAc*<br><br>*Acacia* open woodland over *Aristida* sparse tussock grassland | 9<br>12<br>45<br>46<br>47<br>64<br>67<br>69<br>78<br>89 | *Acacia aptaneura* and *A. pruinocarpa* open woodland over *Aristida contorta* sparse tussock grassland over *Pterocaulon sphacelatum* and *Ptilotus nobilis* subsp. *nobilis* isolated forbs.<br><br>Average species richness = 37.7 ± 2.8<br><br>Sample size = 10 | *Acacia aptaneura*<br>*Pterocaulon sphacelatum*<br>*Ptilotus nobilis* subsp. *nobilis*<br>*Abutilon otocarpum*<br>*Enneapogon polyphyllus*<br>*Aristida contorta*<br>*Acacia pruinocarpa*<br>*Ptilotus helipteroides*<br>*Salsola australis*<br>*Evolvulus alsinoides* var. *villisocalyx*<br>*Triodia pungens*<br>*Senna artemisioides* subsp. *oligophylla*<br>*Senna notabilis* | 505.39 ha<br><br>(2.87%) |  |

| Vegetation unit mapping code | Quadrats | Vegetation description (NVIS Level V) | Associated species | Area km$^2$ (% of Study Area) | Photograph |
|---|---|---|---|---|---|
| *AaSaoTp*<br><br>*Acacia* open woodland over *Senna* sparse shrubland over *Triodia* open hummock grassland | 10<br>19<br>41<br>44<br>54<br>80<br>86<br>154 | *Acacia aptaneura* and *A. ayersiana* open woodland over *Senna artemisioides* subsp. *oligophylla, S. glutinosa* subsp. *glutinosa* and *Eremophila forrestii* subsp. *forrestii* sparse shrubland over *Triodia pungens* open hummock grassland.<br><br>Average species richness = 44.8 ± 2.8<br><br>Sample size = 9 | *Acacia aptaneura*<br>*Senna artemisioides* subsp. *oligophylla*<br>*Senna glutinosa* subsp. *glutinosa*<br>*Aristida contorta*<br>*Evolvulus alsinoides* var. *villisocalyx*<br>*Hibiscus burtonii*<br>*Triodia pungens*<br>*Eremophila forrestii* subsp. *forrestii*<br>*Acacia pruinocarpa*<br>*Eriachne pulchella* subsp. *dominii*<br>*Euphorbia australis*<br>*Sida* sp. spiciform panicles<br>*Acacia ayersiana* | 447.27 ha<br><br>(2.54%) |  |
| *EgSggTb*<br><br>*Eucalyptus* open woodland over *Senna* sparse shrubland over *Triodia* open hummock grassland | 17<br>93<br>116<br>117<br>119<br>122 | *Eucalyptus gamophylla* and *Corymbia deserticola* subsp. *deserticola* open woodland over *Senna artemisioides* subsp. *oligophylla* and *Indigofera monophylla* sparse shrubland over *Triodia basedowii* and *T. pungens* open hummock grassland.<br><br>Average species richness = 32.7 ± 3.5<br><br>Sample size = 6 | *Keraudrenia velutina*<br>*Senna glutinosa* subsp. *glutinosa*<br>*Paraneurachne muelleri*<br>*Ptilotus calostachyus*<br>*Triodia basedowii*<br>*Triodia pungens*<br>*Eucalyptus gamophylla*<br>*Acacia bivenosa*<br>*Acacia adsurgens*<br>*Corymbia deserticola* subsp. *deserticola*<br>*Ptilotus nobilis* subsp. *nobilis*<br>*Solanum lasiophyllum*<br>*Acacia ancistrocarpa^* | 309.52 ha<br><br>(1.76%) |  |
| **Sandy Plain** | | | | | |

| Vegetation unit mapping code | Quadrats | Vegetation description (NVIS Level V) | Associated species | Area km$^2$ (% of Study Area) | Photograph |
|---|---|---|---|---|---|
| *AaEcTp*<br><br>*Acacia* open woodland over *Eremophila* isolated shrubs over *Triodia* open hummock grassland | 29<br>49<br>50<br>53<br>63<br>70<br>71<br>81<br>200 | *Acacia aptaneura* and *A. pruinocarpa* open woodland over *Eremophila caespitosa* and *Tribulus suberosus* isolated shrubs over *Triodia pungens* open hummock grassland.<br><br>Average species richness = 37.2 ± 2.6<br><br>Sample size = 9 | *Acacia aptaneura*<br>*Triodia pungens*<br>*Aristida contorta*<br>*Ptilotus nobilis* subsp. *nobilis*<br>*Senna notabilis*<br>*Acacia pruinocarpa*<br>*Enneapogon polyphyllus*<br>*Ptilotus schwartzii* var. *schwartzii*<br>*Eremophila caespitosa*<br>*Eriachne pulchella* subsp. *dominii*<br>*Tribulus suberosus*<br>*Eragrostis pergracilis*^<br>*Ptilotus roei*^ | 1769.85 ha<br><br>(10.06%) |  |
| *AlAp*<br><br>*Aristida* and *Astrebla* tussock grassland | 21<br>61<br>62<br>66<br>68<br>94<br>95 | *Aristida latifolia, Astrebla pectinata* and *Brachyachne convergens* tussock grassland with isolated *Salsola australis, Boerhavia paludosa* and *Ptilotus nobilis* subsp. *nobilis* forbs.<br><br>Average species richness = 35.0 ± 2.3<br><br>Sample size = 7 | *Astrebla pectinata*<br>*Aristida latifolia*<br>*Salsola australis*<br>*Brachyachne convergens*^<br>*Ptilotus nobilis* subsp. *nobilis*<br>*Boerhavia paludosa*<br>*Iseilema vaginiflorum*<br>*Panicum decompositum*<br>*Pterocaulon sphacelatum*<br>*Sida spinosa*^<br>*Hibiscus trionum*^<br>*Themeda* sp. Hamersley Station^ | 302.23 ha<br><br>(1.72%) |  |

| Vegetation unit mapping code | Quadrats | Vegetation description (NVIS Level V) | Associated species | Area km$^2$ (% of Study Area) | Photograph |
|---|---|---|---|---|---|
| *PsTp*<br><br>*Pterocaulon* sparse forbland with *Triodia* open hummock grassland | 51<br>52<br>108 | *Acacia aptaneura* or *A. ayersiana* open woodland over *Pterocaulon sphacelatum* and *Dysphania kalparri* sparse forbland with *Triodia pungens* open hummock grassland.<br><br>Average species richness = 36.7 ± 2.6<br><br>Sample size = 3 | *Pterocaulon sphacelatum*<br>*Dysphania kalpari*<br>*Aristida contorta*<br>*Enneapogon polyphyllus*<br>*Aristida jerichoensis* var. *subspinulifera*^<br>*Cucumis variabilis*<br>*Euphorbia drummondii*<br>*Panicum effusum*<br>*Sida* sp. verrucose glands<br>*Triodia pungens*<br>*Themeda triandra* | 174.39 ha<br><br>(0.99%) |  |
| **Sandy Undulating Plain** | | | | | |
| *AaTp*<br><br>*Acacia* woodland over *Triodia* open hummock grassland | 18<br>48<br>77<br>91<br>115<br>118 | *Acacia pruinocarpa, A. aptaneura* and *A. ayersiana* woodland over *Triodia pungens* open hummock grassland.<br><br>Average species richness = 29.3 ± 3.9<br><br>Sample size = 6 | *Acacia aptaneura*<br>*Triodia pungens*<br>*Acacia pruinocarpa*<br>*Aristida contorta*<br>*Hibiscus burtonii*<br>*Solanum lasiophyllum*<br>*Acacia ayersiana*<br>*Enneapogon polyphyllus*<br>*Ptilotus nobilis* subsp. *nobilis*<br>*Ptilotus obovatus*<br>*Senna glutinosa* subsp. *glutinosa* | 982.26 ha<br><br>(5.58%) |  |




**Absolute Scale - 1:130,000**

## Legend

- Quadrat locations

### Vegetation Units

*AaAc* — *Acacia aptaneura* and *A. pruinocarpa* open woodland over *Aristida contorta* sparse tussock grassland over *Pterocaulon sphacelatum* and *Ptilotus nobilis* subsp. *nobilis* isolated forbs

*AaEffTp* — *Acacia aptaneura* and *A. pruinocarpa* open woodland over sparse *Eremophila fraseri* subsp. *fraseri* and *Acacia marramamba* sparse shrubland over *Triodia pungens* sparse hummock grassland

*AaPoTp* — *Acacia aptaneura* open woodland over *Ptilotus obovatus* isolated shrubs over *Themeda triandra* and *Eriachne mucronata* open tussock grassland

*AaPoTt* — *Acacia aptaneura* open woodland over *Ptilotus obovatus* sparse shrubland over *Themeda triandra* open tussock grassland

*AaSaoTp* — *Acacia aptaneura* and *A. ayersiana* open woodland over *Senna artemisioides* subsp. *oligophylla*, *S. glutinosa* subsp. *glutinosa* and *Eremophila forrestii* subsp. *forrestii* sparse shrubland over *Triodia pungens* open hummock grassland

*AaTssp* — *Acacia aptaneura* and *A. pruinocarpa* open woodland over *A. tetragonophylla*, *Senna glutinosa* subsp. *glutinosa* and *S. artemisioides* subsp. *oligophylla* isolated shrubs over *Triodia wiseana* and *T. pungens* open hummock grassland

*AaTp* — *Acacia pruinocarpa*, *A. aptaneura* and *A. ayersiana* woodland over *Triodia pungens* open hummock grassland

*Tp* — *Eucalyptus leucophloia* subsp. *leucophloia* and *Acacia pruinocarpa* isolated trees over *Senna glutinosa* subsp. *glutinosa*, *A. bivenosa* and *Ptilotus rotundifolius* isolated shrubs over *Triodia pungens* or *T. basedowii* or *T.* sp. Mt Ella hummock grassland

*EliSggTw* — *Eucalyptus leucophloia* subsp. *leucophloia* and *Acacia aptaneura* open woodland over *Senna glutinosa* subsp. *glutinosa* and *S. artemisioides* subsp. *oligophylla* open shrubland over *Triodia wiseana* or *T. pungens* open hummock grassland

*EllAmTssp* — *Eucalyptus leucophloia* subsp. *leucophloia* and *E. gamophylla* open woodland over *Acacia maitlandii*, *A. hamersleyensis*, *Keraudrenia velutina* and *Senna glutinosa* subsp. *glutinosa* open shrubland over *Triodia wiseana* and/or *T. pungens* and/or *T. basedowii* open hummock grassland

*AmTw* — *Eucalyptus leucophloia* subsp. *leucophloia* isolated trees over *Acacia maitlandii* sparse shrubland over *Triodia wiseana* and *T. longiceps* hummock grassland

*ApEcTp* — *Acacia aptaneura* and *A. pruinocarpa* open woodland over *Eremophila caespitosa* and *Tribulus suberosus* isolated shrubs over *Triodia pungens* open hummock grassland

*ApTssp* — *Acacia pruinocarpa* and *Eucalyptus leucophloia* subsp. *leucophloia* open woodland over *Senna glutinosa* subsp. *glutinosa* and *A. maitlandii* isolated shrubs over *Triodia basedowii* or *T. pungens* or *T. wiseana* open hummock grassland

*AaTb* — *Acacia aptaneura* and *A. pruinocarpa* open woodland over *A. bivenosa* isolated shrubs *Triodia basedowii* and *T. pungens* open hummock grassland

*SggTp* — *Eucalyptus leucophloia* subsp. *leucophloia* and *Corymbia hamersleyana* isolated trees over *Senna glutinosa* subsp. *glutinosa* and *Acacia maitlandii* sparse shrubland over *Triodia pungens* open hummock grassland

*EgSggTb* — *Eucalyptus gamophylla* and *Corymbia deserticola* subsp. *deserticola* open woodland over *Senna artemisioides* subsp. *oligophylla* and *Indigofera monophylla* sparse shrubland over *Triodia basedowii* and *T. pungens* open hummock grassland

*EllSggTp* — *Eucalyptus leucophloia* subsp. *leucophloia* and *Acacia marramambra* open woodland over *Senna glutinosa* subsp. *glutinosa* open shrubland over *Triodia pungens* open hummock grassland

*AaTt* — *Acacia aptaneura* and *Eucalyptus xerothermica* woodland over *Ptilotus obovatus* isolated shrubs over *Themeda triandra* open tussock grassland

*AlAp* — *Aristida latifolia*, *Astrebla pectinata* and *Brachyachne convergens* tussock grassland with isolated *Salsola australis*, *Boerhavia paludosa* and *Ptilotus nobilis* subsp. *nobilis* forbs

*PsTp* — *Acacia aptaneura* or *A. ayersiana* open woodland over *Pterocaulon sphacelatum* and *Dysphania kalparri* sparse forbland with *Triodia pungens* open hummock grassland

*SggAbTp* — *Acacia pruinocarpa* and *Eucalyptus leucophloia* subsp. *leucophloia* or *Corymbia hamersleyana* isolated trees over *Senna glutinosa* subsp. *glutinosa*, *Acacia bivenosa* and *Gossypium robinsonii* open shrubland over *Triodia pungens* hummock grassland

*SggIrTw* — *Acacia inaequilatera* isolated trees over *Senna glutinosa* subsp *glutinosa* and *Indigofera rugosa* open shrubland over *Triodia wiseana* hummock grassland

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# Overview of Vegetation Units at Greater West Angelas

**Figure: 5.3**
**Project ID: 1457**

**Drawn: CP**
**Date: 04/02/2013**

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

Unique Map ID: MXXX

**A3**

686000 688000 690000

7444000

7442000

**Legend**

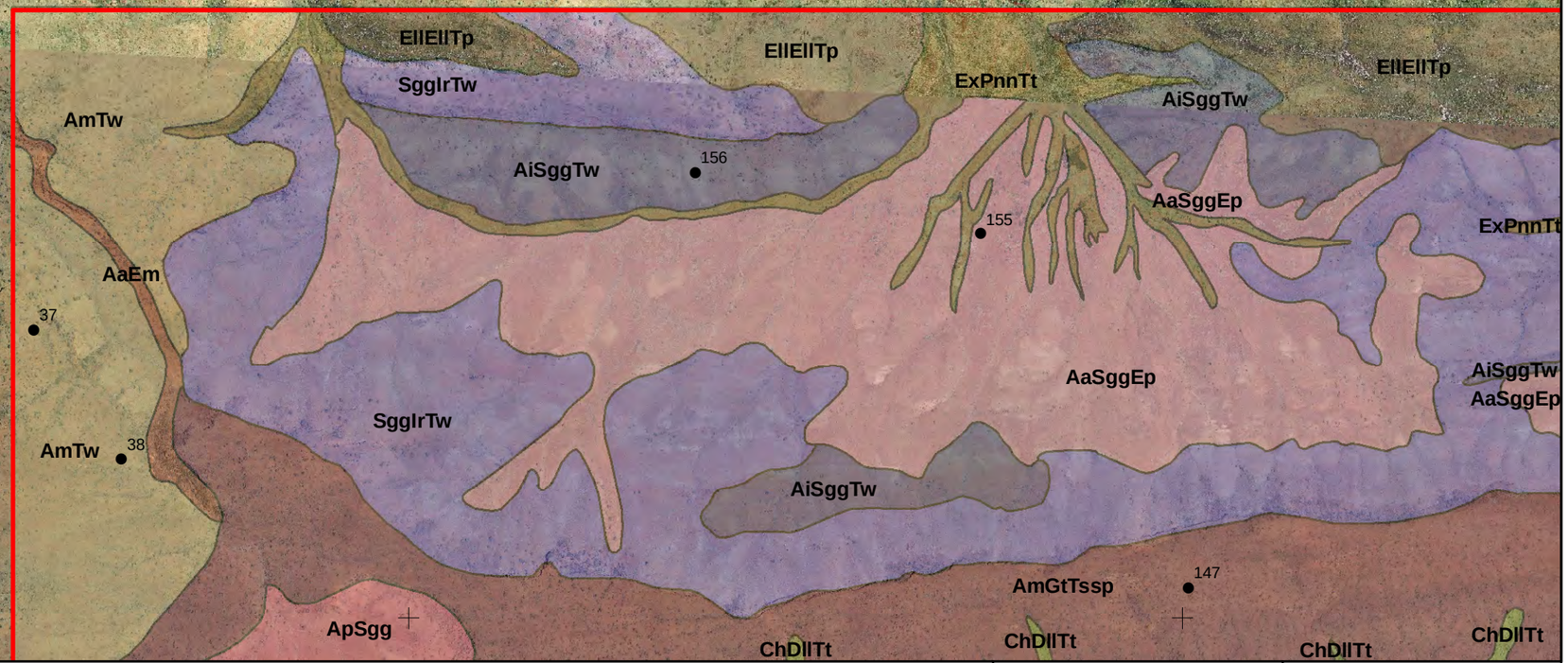
Study Area

Quadrat locations

**Vegetation Units**

- *AaAc*
- *AaEffTp*
- *AaPoTp*
- *AaPoTt*
- *AaSaoTp*
- *AaTssp*
- *AaTp*
- *Tp*
- *EllSggTw*
- *ElAmTssp*
- *AmTw*
- *ApEcTp*
- *ApTssp*
- *AaTb*
- *SggTp*
- *EgSggTb*
- *EllSggTp*
- *AaTt*
- *AlAp*
- *PsTp*
- *SggAbTp*
- *SggIrTw*

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# Vegetation Units within the West Angelas Study Area
# Map A5

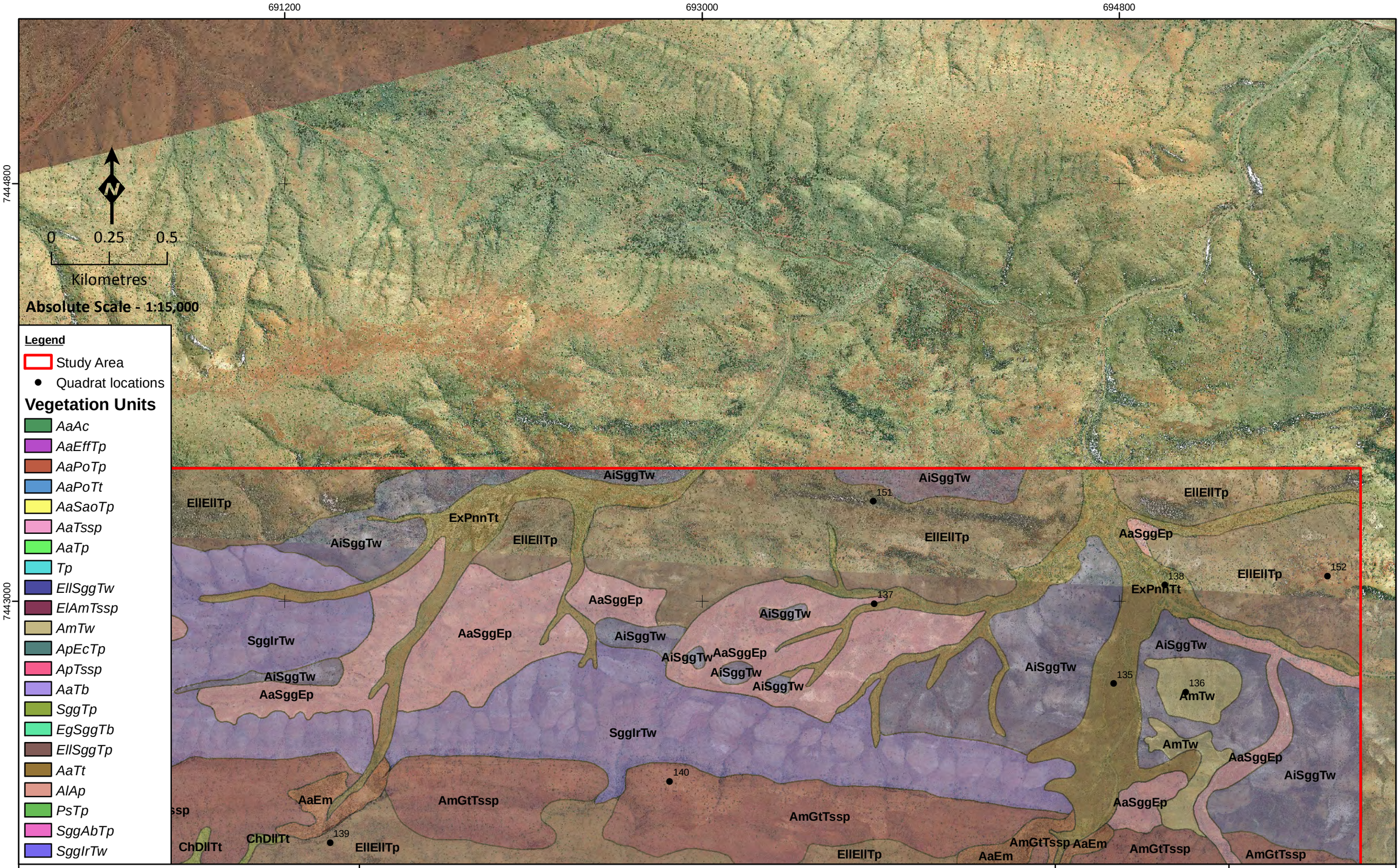
**Figure: 5.4**
**Project ID: 1457**

**Drawn: CP**
**Date: 23/11/2012**

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

Unique Map ID: CP153

**A3**

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# Vegetation Units within the West Angelas Study Area
# Map A6

**Figure: 5.5**
**Project ID: 1457**

**Drawn: CP**
**Date: 23/11/2012**

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

Unique Map ID: CP153

A3

662400 664200 666000 667800

7441200

7439400

N

0 0.25 0.5

Kilometres

**Absolute Scale - 1:15,000**

**Legend**

- Study Area
- Quadrat locations

**Vegetation Units**

- *AaAc*
- *AaEffTp*
- *AaPoTp*
- *AaPoTt*
- *AaSaoTp*
- *AaTssp*
- *AaTp*
- *Tp*
- *EllSggTw*
- *ElAmTssp*
- *AmTw*
- *ApEcTp*
- *ApTssp*
- *AaTb*
- *SggTp*
- *EgSggTb*
- *EllSggTp*
- *AaTt*
- *AlAp*
- *PsTp*
- *SggAbTp*
- *SggIrTw*

71 72 84 65

AaEm ApEcTp AaPoEp AaEffTp ApTb AaSlTp AaEffTpApTb SggGrTp AbPrIa AaSggEp EllElTp AiSggTw

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# Vegetation Units within the West Angelas Study Area
# Map B1

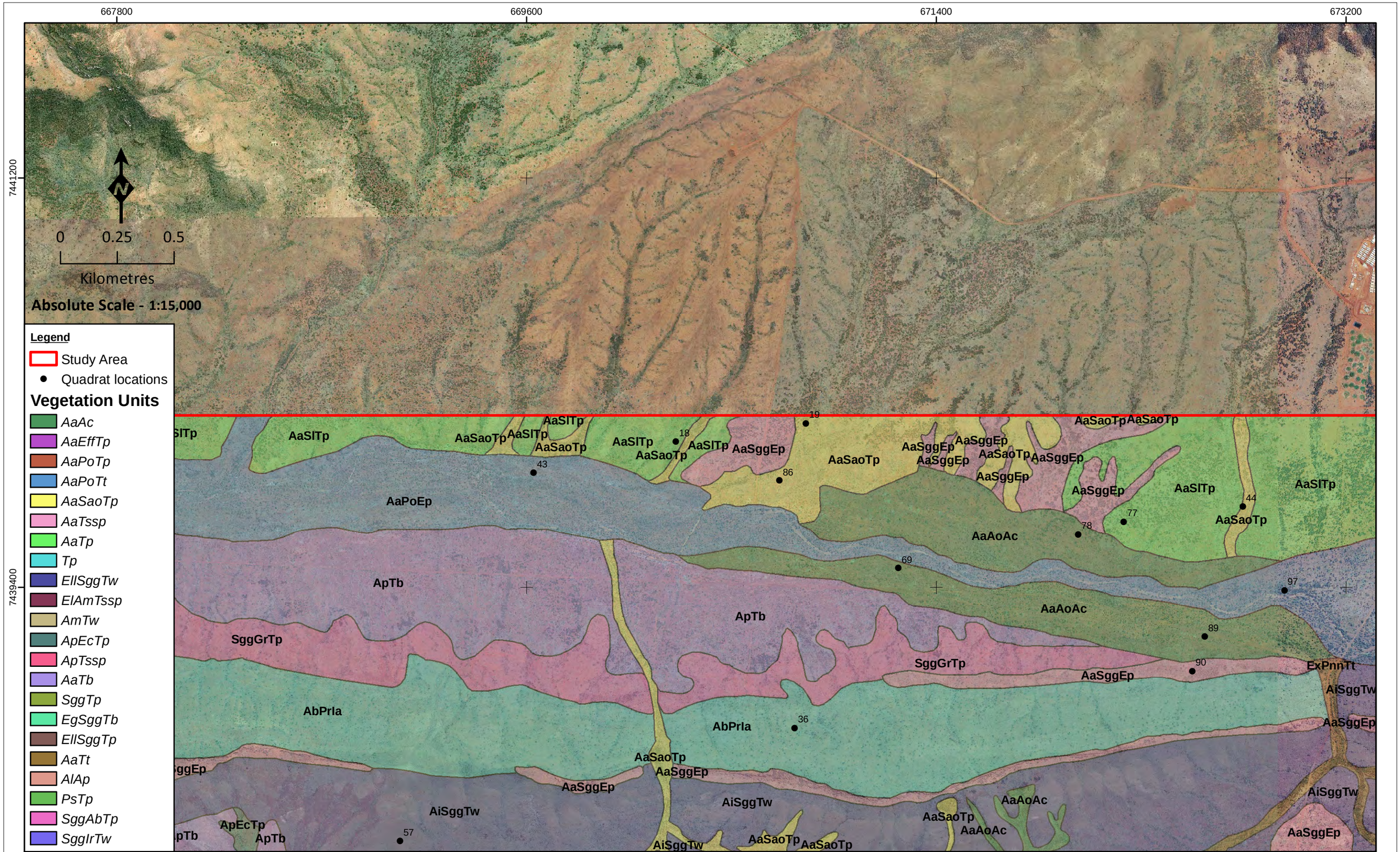
**Figure: 5.6**
**Project ID: 1457**

**Drawn: CP**
**Date: 23/11/2012**

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

Unique Map ID: CP153

**A3**

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# Vegetation Units within the West Angelas Study Area
# Map B2

**Figure: 5.7**
**Project ID: 1457**

**Drawn: CP**
**Date: 23/11/2012**

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

Unique Map ID: CP153

A3

675000 676800 678600

7441200

7439400

**Legend**

Study Area

Quadrat locations

**Vegetation Units**

*AaAc*
*AaEffTp*
*AaPoTp*
*AaPoTt*
*AaSaoTp*
*AaTssp*
*AaTp*
*Tp*
*EllSggTw*
*ElAmTssp*
*AmTw*
*ApEcTp*
*ApTssp*
*AaTb*
*SggTp*
*EgSggTb*
*EllSggTp*
*AaTt*
*AlAp*
*PsTp*
*SggAbTp*
*SggIrTw*

AaSlTp AmGtTssp AiSggTw AaSaoTp AaPoEp AaAoAc SggGrTp ExPnnTt PnnAp ApEcTp AaSggEp

56 10 141 7 9 8 6 2 87 94 96 35 82 79 76 68 67 42 5

0 0.25 0.5

Kilometres

**Absolute Scale - 1:15,000**

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# Vegetation Units within the West Angelas Study Area
# Map B3

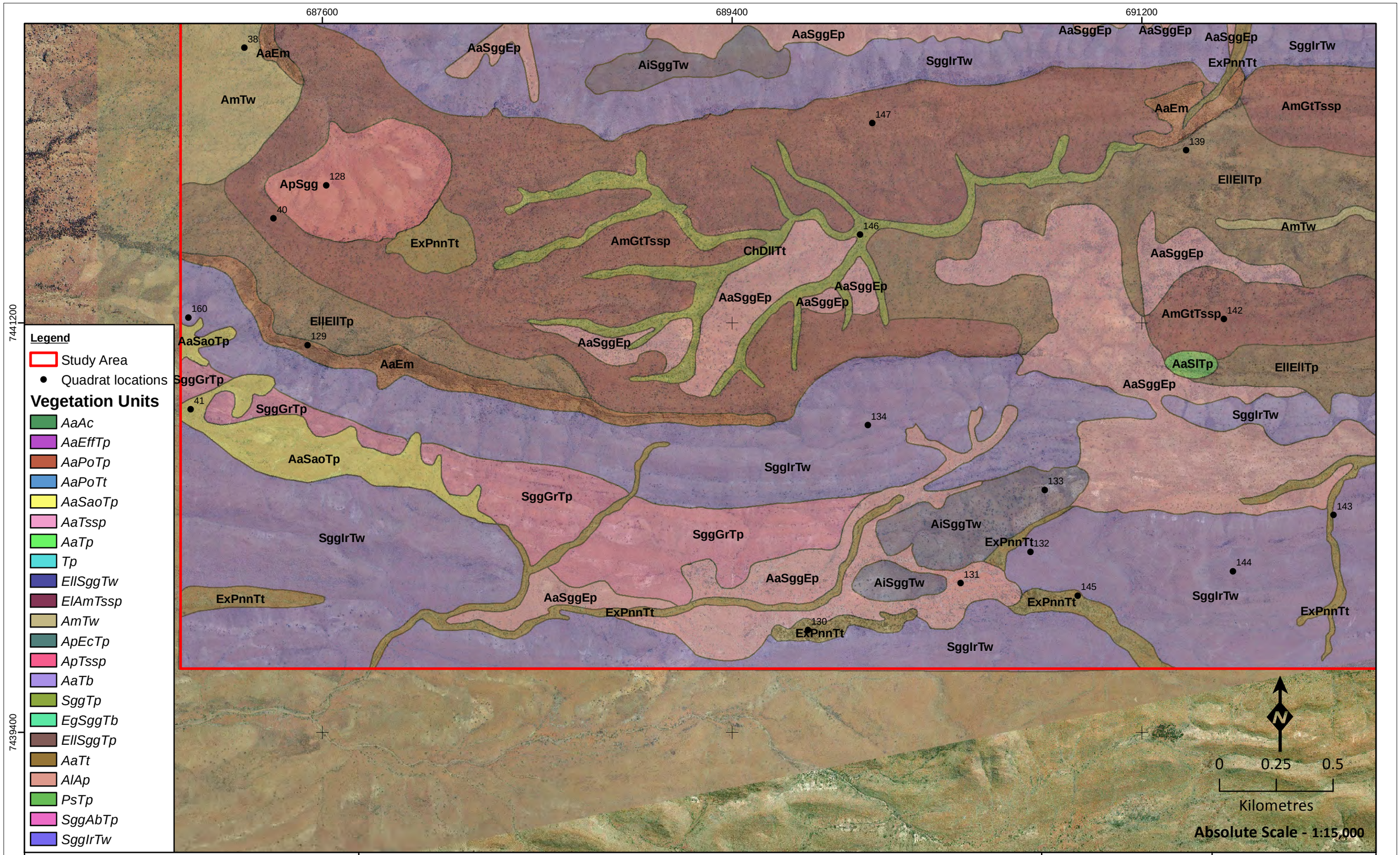
**Figure: 5.8**
**Project ID: 1457**

**Drawn: CP**
**Date: 23/11/2012**

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

Unique Map ID: CP153

**A3**

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# Vegetation Units within the West Angelas Study Area
# Map B5

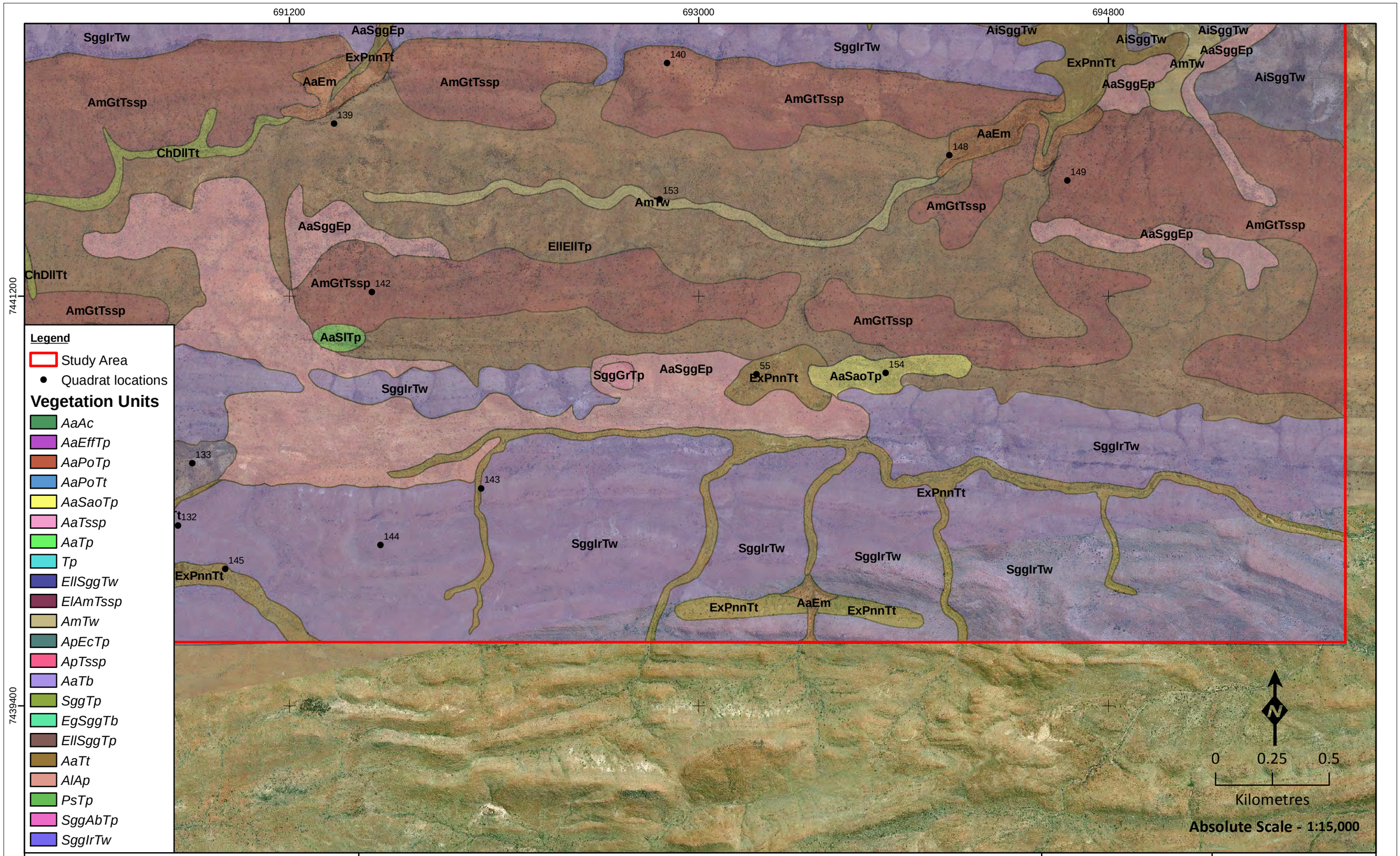
**Figure: 5.9**
**Project ID: 1457**

**Drawn: CP**
**Date: 23/11/2012**

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

Unique Map ID: CP153

A3

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**Vegetation Units within the West Angelas Study Area**
**Map B6**

**Figure: 5.10**
**Project ID: 1457**

**Drawn: CP**
**Date: 23/11/2012**

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

Unique Map ID: CP153

A3

662400 664200 666000 667800

7437600

7435800

N

0 0.25 0.5

Kilometres

**Absolute Scale - 1:15,000**

**Legend**

Study Area

Quadrat locations

**Vegetation Units**

- *AaAc*
- *AaEffTp*
- *AaPoTp*
- *AaPoTt*
- *AaSaoTp*
- *AaTssp*
- *AaTp*
- *Tp*
- *EllSggTw*
- *ElAmTssp*
- *AmTw*
- *ApEcTp*
- *ApTssp*
- *AaTb*
- *SggTp*
- *EgSggTb*
- *EllSggTp*
- *AaTt*
- *AlAp*
- *PsTp*
- *SggAbTp*
- *SggIrTw*

AaEffTp
ApEcTp
AaSggEp
AaSggEp
AaSggEp
EllEllTp
AbPrIa
AaSggEp
EllEllTp
24
28
74
AaSggEp
AbPrIa
AaSggEp
AaSggEp
AiSggTw
EllEllTp
AaEm
27
AaSggEp
ApTb
ApTb
29
26
EllEllTp
AaSaoTp
SggGrTp
ApSgg
58
70
ApEcTp
ApTb
75
ApEcTp
53
EgKvPm
81
EgKvPm
54
AaAoAc
ApEcTp
AaSaoTp
80
ApTb
16
EgKvPm
EgKvPm
ApTb
ApTb
EgKvPm
17
ApTb
EgKvPm
ApTb
EgKvPm
ApTb
ApEcTp
EgKvPm
SggGrTp
EllEllTp

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# Vegetation Units within the West Angelas Study Area
# Map C1

**Figure: 5.11**
**Project ID: 1457**

**Drawn: CP**
**Date: 23/11/2012**

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

Unique Map ID: CP153

**A3**

667800 669600 671400 673200

7437600

7435800

N

0 0.25 0.5

Kilometres

**Absolute Scale - 1:15,000**

**Legend**

Study Area

Quadrat locations

**Vegetation Units**

*AaAc*
*AaEffTp*
*AaPoTp*
*AaPoTt*
*AaSaoTp*
*AaTssp*
*AaTp*
*Tp*
*EllSggTw*
*ElAmTssp*
*AmTw*
*ApEcTp*
*ApTssp*
*AaTb*
*SggTp*
*EgSggTb*
*EllSggTp*
*AaTt*
*AlAp*
*PsTp*
*SggAbTp*
*SggIrTw*

AbPrIa AaSggEp AaSggEp AbPrIa AaSggEp ExPnnTt AaSggEp AiSggTw AaSaoTp AaAoAc ApEcTp ApTb AiSggTw ApTb AiSggTw PnnAp ApTb ApEcTp ExPnnTt AaAoAc ExPnnTt PnnAp ApEcTp AbPrIa AbPrIa AaSggEp EgKvPm ApEcTp AaEffTp AaAoAc ApEcTp PnnAp AaSlTp ApEcTp EgKvPm EgKvPm ApEcTp ApTb ApEcTp SggGrTp ApTb SggGrTp ApEcTp

36 57 64 66 21 12 49

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# Vegetation Units within the West Angelas Study Area
# Map C2

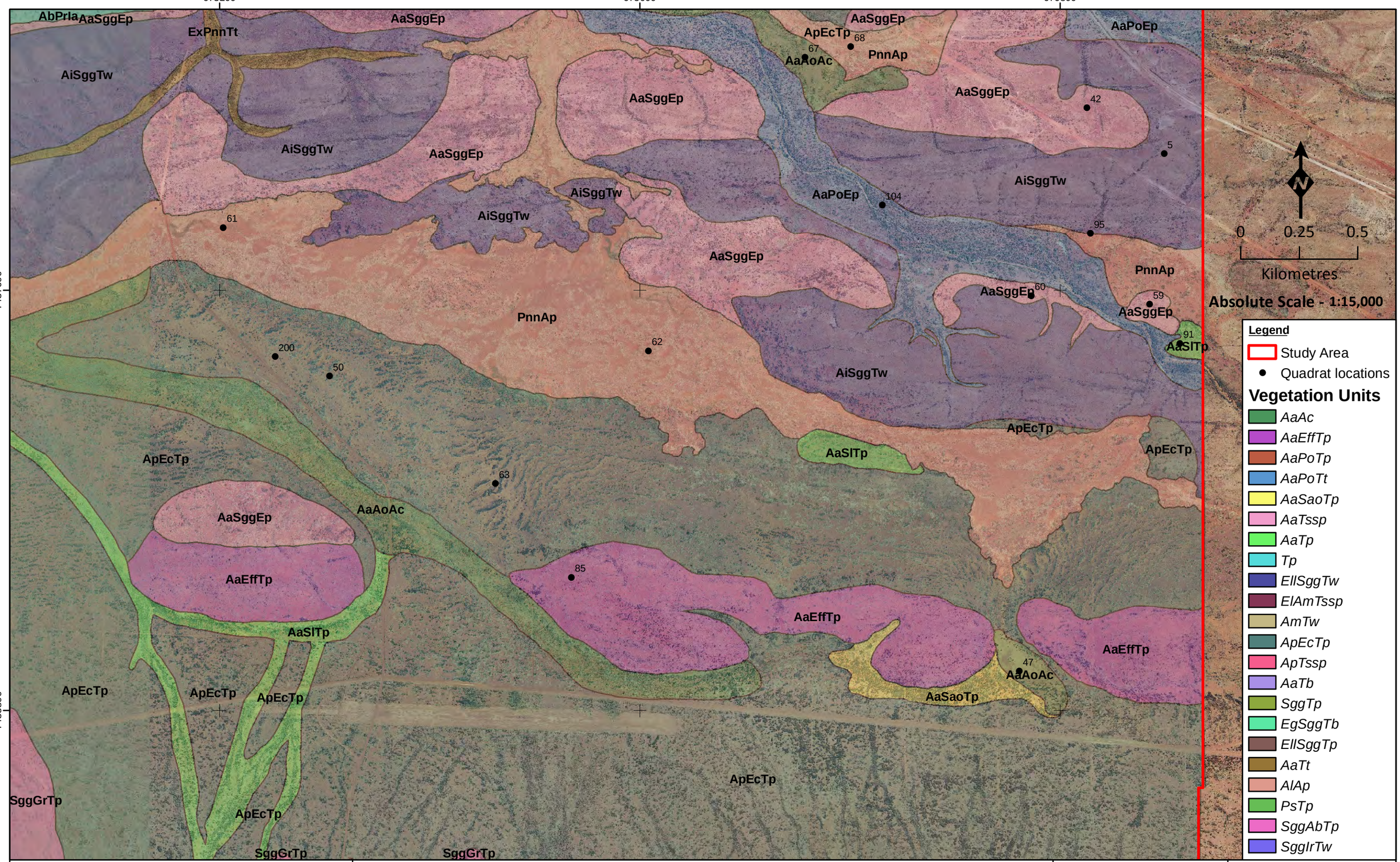
**Figure: 5.12**
**Project ID: 1457**

**Drawn: CP**
**Date: 23/11/2012**

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

Unique Map ID: CP153

**A3**

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**Vegetation Units within the West Angelas Study Area**
**Map C3**

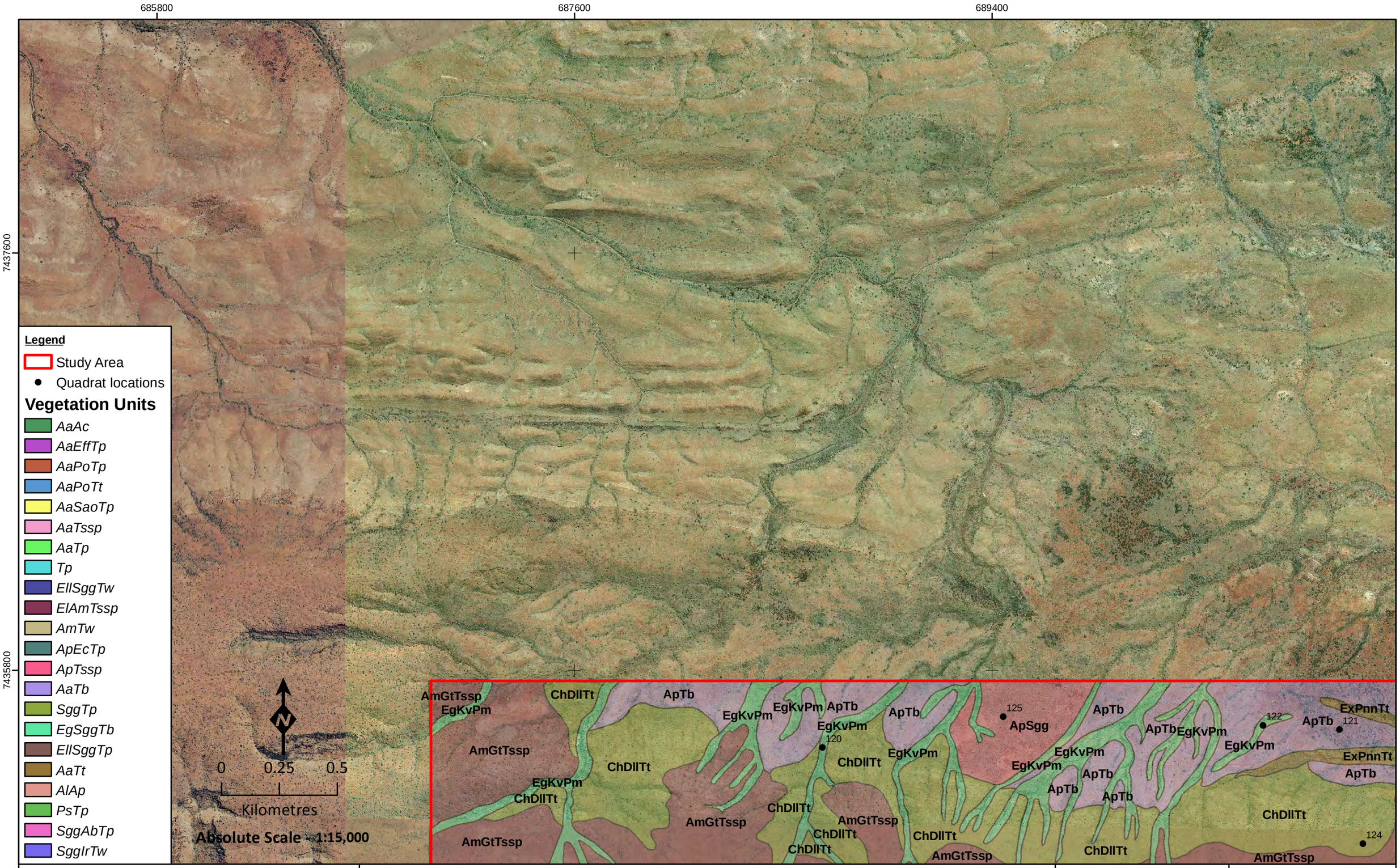
**Figure: 5.13**
**Project ID: 1457**

**Drawn: CP**
**Date: 23/11/2012**

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

Unique Map ID: CP153

A3

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# Vegetation Units within the West Angelas Study Area
# Map C5

**Figure: 5.14**
**Project ID: 1457**

**Drawn: CP**
**Date: 23/11/2012**

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

Unique Map ID: CP153

A3

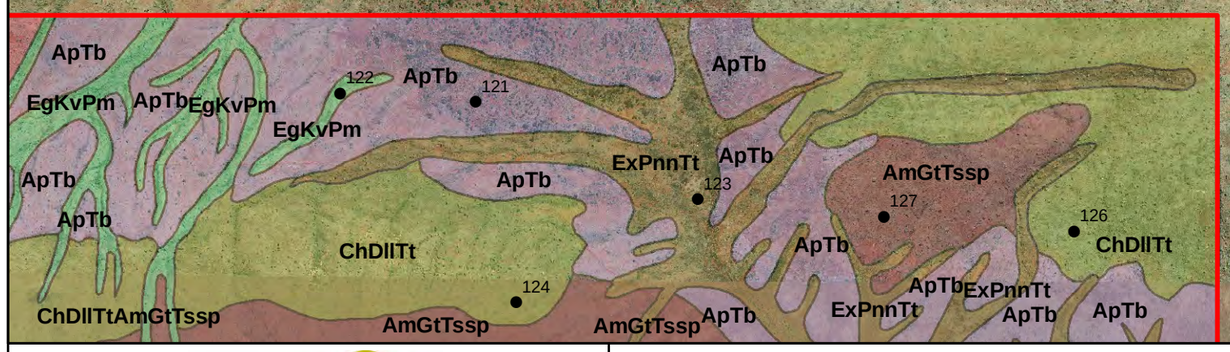
691200

693000

694800

7437600

7435800




**Legend**

- Study Area
- Quadrat locations

**Vegetation Units**

- *AaAc*
- *AaEffTp*
- *AaPoTp*
- *AaPoTt*
- *AaSaoTp*
- *AaTssp*
- *AaTp*
- *Tp*
- *EllSggTw*
- *ElAmTssp*
- *AmTw*
- *ApEcTp*
- *ApTssp*
- *AaTb*
- *SggTp*
- *EgSggTb*
- *EllSggTp*
- *AaTt*
- *AlAp*
- *PsTp*
- *SggAbTp*
- *SggIrTw*

N

0 0.25 0.5

Kilometres

**Absolute Scale - 1:15,000**

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# Vegetation Units within the West Angelas Study Area
# Map C6

**Figure: 5.15**
**Project ID: 1457**

**Drawn: CP**
**Date: 23/11/2012**

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

Unique Map ID: CP153

**A3**

664200 666000 667800

7434000

7432200

N

0 0.25 0.5

Kilometres

,000

**Legend**

Study Area

Quadrat locations

**Vegetation Units**

- *AaAc*
- *AaEffTp*
- *AaPoTp*
- *AaPoTt*
- *AaSaoTp*
- *AaTssp*
- *AaTp*
- *Tp*
- *EllSggTw*
- *ElAmTssp*
- *AmTw*
- *ApEcTp*
- *ApTssp*
- *AaTb*
- *SggTp*
- *EgSggTb*
- *EllSggTp*
- *AaTt*
- *AlAp*
- *PsTp*
- *SggAbTp*
- *SggIrTw*

ApTb EgKvPm EgKvPm EgKvPm ApTb ApTb

SggGrTp ApEcTp EgKvPm 14 EgKvPm

EllElTp 15 AbPrla EgKvPm SggGrTp

3 AaSaoTp

SggGrTp EgKvPm AbPrla

93 EgKvPm SggGrTp EllElTp

AbPrla AaEm

EgKvPm AaSaoTp AaSlTp EllElTp

100 AaSggEp

20 AmGtTssp

EllElTp 31 AaSaoTp AaPoEp

103 EllElTp AaEm

AaSggEp 25 AaEm AaSaoTp

11 EllElTp EllElTp EllElTp EllElTp

AaEm EllElTp

EllElTp

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# Vegetation Units within the West Angelas Study Area
# Map D1

**Figure: 5.16**
**Project ID: 1457**

**Drawn: CP**
**Date: 23/11/2012**

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

Unique Map ID: CP153

**A3**

667800 669600 671400 673200

7434000

7432200

ApEcTp ApTb EgKvPm SggGrTp AbPrIa AaSlTp EllEllTp AaEm ApSgg AaSaoTp ExPnnTt AmGtTssp

92 48 33 30

N

0 0.25 0.5

Kilometres

**Legend**

Study Area

Quadrat locations

**Vegetation Units**

- *AaAc*
- *AaEffTp*
- *AaPoTp*
- *AaPoTt*
- *AaSaoTp*
- *AaTssp*
- *AaTp*
- *Tp*
- *EllSggTw*
- *ElAmTssp*
- *AmTw*
- *ApEcTp*
- *ApTssp*
- *AaTb*
- *SggTp*
- *EgSggTb*
- *EllSggTp*
- *AaTt*
- *AlAp*
- *PsTp*
- *SggAbTp*
- *SggIrTw*

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# Vegetation Units within the West Angelas Study Area Map D2

**Figure: 5.17**
**Project ID: 1457**

**Drawn: CP**
**Date: 23/11/2012**

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

Unique Map ID: CP153

**A3**

673200 675000 676800 678600

7434000

7432200

ApEcTp
ApEcTp
ApEcTp
48
SggGrTp
AaSlTp
SggGrTp
102
AbPrIa
SggGrTp
22
AbPrIa
23
34
4
EllEllTp
ApSgg
EllEllTp
AaEm
AaEm
ApSgg
AbPrIa
EllEllTp
AaEm
EllEllTp
AaPoEp

**Legend**

- Study Area
- Quadrat locations

**Vegetation Units**

- *AaAc*
- *AaEffTp*
- *AaPoTp*
- *AaPoTt*
- *AaSaoTp*
- *AaTssp*
- *AaTp*
- *Tp*
- *EllSggTw*
- *ElAmTssp*
- *AmTw*
- *ApEcTp*
- *ApTssp*
- *AaTb*
- *SggTp*
- *EgSggTb*
- *EllSggTp*
- *AaTt*
- *AlAp*
- *PsTp*
- *SggAbTp*
- *SggIrTw*

N

0 0.25 0.5

Kilometres

**Absolute Scale - 1:15,000**

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# Vegetation Units within the West Angelas Study Area
# Map D3

**Figure: 5.18**
**Project ID: 1457**

**Drawn: CP**
**Date: 23/11/2012**

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

Unique Map ID: CP153

**A3**

685800 687600 689400 691200

7434000

7432200

**Legend**

- Study Area
- Quadrat locations

**Vegetation Units**

- *AaAc*
- *AaEffTp*
- *AaPoTp*
- *AaPoTt*
- *AaSaoTp*
- *AaTssp*
- *AaTp*
- *Tp*
- *EllSggTw*
- *ElAmTssp*
- *AmTw*
- *ApEcTp*
- *ApTssp*
- *AaTb*
- *SggTp*
- *EgSggTb*
- *EllSggTp*
- *AaTt*
- *AlAp*
- *PsTp*
- *SggAbTp*
- *SggIrTw*

N

0 0.25 0.5

Kilometres

**Absolute Scale - 1:15,000**

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# Vegetation Units within the West Angelas Study Area
# Map D5

**Figure: 5.19**
**Project ID: 1457**

**Drawn: CP**
**Date: 23/11/2012**

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

Unique Map ID: CP153

**A3**

689400 691200 693000 694800

7434000

7432200

ApSgg ApTb EgKvPm ApTb ApTb EgKvPm ApTb EgKvPm ApTb ApTb EgKvPm ChDllTt EgKvPm ChDllTt ChDllTt ApTb ApTb ApTb 123 ApTb 127 AmGtTssp 126 ChDllTt 124 ApTb ApTb ApTb AbPrIa AbPrIa AmGtTssp ChDllTt 111 AbPrIa ChDllTt 106 AbPrIa 99 ExPnnTt ApTb ApTb AaSlTp 98 SggGrTp AmGtTssp 105 112 ChDllTt 107 ApTb ApTb 109 115 114 ApTb PsAjs AaSlTp EgKvPm 116 EgKvPm 118 117 EgKvPm

**Legend**

- Study Area
- Quadrat locations

**Vegetation Units**

- *AaAc*
- *AaEffTp*
- *AaPoTp*
- *AaPoTt*
- *AaSaoTp*
- *AaTssp*
- *AaTp*
- *Tp*
- *EllSggTw*
- *ElAmTssp*
- *AmTw*
- *ApEcTp*
- *ApTssp*
- *AaTb*
- *SggTp*
- *EgSggTb*
- *EllSggTp*
- *AaTt*
- *AlAp*
- *PsTp*
- *SggAbTp*
- *SggIrTw*

N

0 0.25 0.5

Kilometres

**Absolute Scale - 1:15,000**

ecologia ENVIRONMENT

# Vegetation Units within the West Angelas Study Area
# Map D6

**Figure: 5.20**
**Project ID: 1457**

**Drawn: CP**
**Date: 23/11/2012**

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

Unique Map ID: CP153

**A3**

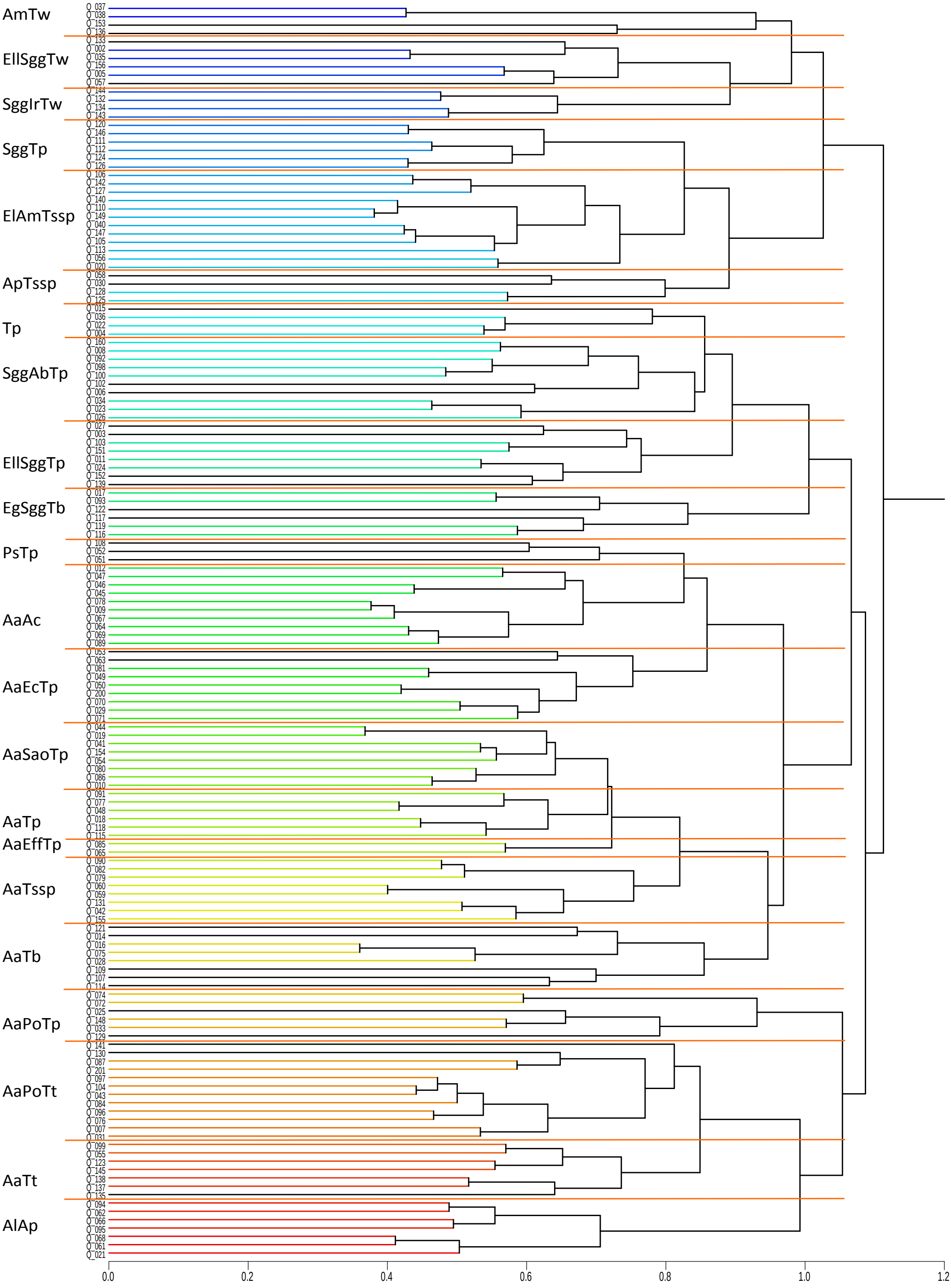


Figure 5.21 - Dendrogram of similarities between quadrats (SYSTAT)

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# 6 DISCUSSION

The significance of the vegetation and flora of the Study Area has been assessed at four scales: national, state, regional and local.

National significance refers to those features of the environment which are recognised under legislation as being of importance to the Australian community. Flora species and Threatened Ecological Communities (TECs) listed under the EPBC Act are regarded as nationally significant.

State significance refers to those features of the environment that are recognised under state legislation as being of importance to the Western Australian community. It includes species that are listed as Threatened under the WC Act and TECs and PECs listed by the DEC, or vegetation which supports fauna of scheduled status.

Regional significance addresses the representation of species and habitats at a biogeographical level. That is, species or habitat types that are endemic to the Hamersley sub-region or whose distributions are limited or unknown are considered regionally significant.

Vegetation and flora species are of local significance when their presence is confined to a very locallised area or a specialised habitat type that is not common in the local or regional contaxt and whose disturbance or removal may lead to local extinction.

## 6.1 FLORISTIC RICHNESS

Species richness is a fundamental measurement of community and regional diversity (Gotelli and Colwell 2001). It is the simplest representation of species diversity (Magurran 1988, Fowler and Cohen 1990) and is the basic indicator of diversity used for this survey.

Table 6.1 compares the floristic inventory recorded during the current survey to that recorded in other quadrat-based surveys conducted in the Pilbara. The most directly comparable survey was in 1998 of the Turee Study Area by ME Trudgen & Associates (1998) which was also a large scale survey. In ME Trudgen & Associates a larger area was survyed, encapusulating a greater range of habitats/landsystems which also resulted in a greater number of taxa recorded.

A comparison of survey intensity with that of the remaining previous projects is difficult due to the differing scales of survey sizes.

The survey intensity of the current study (0.85 quadrats/km$^2$) is considered adequate to the area surveyed; which is reflected in the high number of taxa recorded for its scale.

**Table 6.1 – A Comparison of Floristic Richness of Study Area with Nearby Studies**

| Study Site | Date Surveyed | Number Quadrats Surveyed | Area ($km^2$) | Quadrats /$km^2$ | Number Taxa Recorded | Number of Taxa/ $km^2$ |
|---|---|---|---|---|---|---|
| Current study | June-August 2012 | 149 | 175 | 0.85 | 431 | 2.46 |
| ME Trudgen & Associates 1998 | May-Aug 2011 | - | 353 | - | 635 | 1.80 |
| Biota 2010 | May-12 | 37 | 10 | 3.70 | 262 | 26.20 |
| Rio Tinto 2010 | April-10 | 17 | 5 | 3.40 | 184 | 36.80 |
| Biota 2006 | May-04 | 41 | 19 | 2.16 | 429 | 22.58 |

### 6.1.1 Flora of National Significance

*Lepidium catapycnon* is the most significant taxon with regards to conservation status recorded within the current survey and is listed as vulnerable under the EPBC Act. Descriptions of the EPBC Act vulnerability codes can be found in Appendix D. Fourteen other collection points are lodged at the West Australian Herbarium, located within Western Australia and in close proximity each other. Based on collections from the current survey, this taxon is not abundant within the West Angelas Study Area, with 29 individuals from four locations recorded, however further targeted surveys have the potential to expand the known population. There is one known location from within the conservation estate.

*Lepidium catapycnon* appears to favour the outer edge of creek vegetation and rocky scree slopes that consist of orange-brown (terracotta) coloured clay-loam soil; and it is also favourable to areas where disturbance has exposed sub-soils, particularly of the calcareous type. Thirteen other locations of *Lepidium catapycnon* occur regionally within 40 km of the Study Area, suggesting that the taxon is likely to occur elsewhere within the Study Area (Figure 5.9 and Table 2.8).

The main threat to *L. catapycnon* is mining and exploration activities as its preferred habitat and the majority of recorded populations occur within mining and exploration tenements (Threatened Species Scientific Committee 2008). Processes which have been identified as potential threats to this species include roadworks, as it tends to prefer recently disturbed areas and colonises graded mining and exploration tracks (Threatened Species Scientific Committee 2008). The spread of the introduced species Ruby Dock (*Acetosa vesicaria*, which was also recorded within the Study Area) has been suggested to prevent establishment of this species in some areas (Threatened Species Scientific Committee 2008).

### 6.1.2 Flora of State Significance

*Lepidium catapycnon,* as above, is listed as Threatened (formerly Declared Rare Flora) under the WC Act.

### 6.1.3 Flora of Regional Significance

Thirteen Threatened and Priority Flora taxa were recorded by *ecologia* during the current survey: one Threatened (*Lepidium catapycnon*), three Priority 1 species (*Aristida jerichoensis* var. *subspinulifera, Brachyscome* sp. Wanna Munna Flats (S. van Leeuwen 4662) and *Brunonia* sp. long hairs (D.E. Symon 2440), two Priority 2 species (*Aristida lazaridis* and *Eremophila forrestii* subsp. Pingandy (M.E.

Trudgen 2662), six Priority 3 species (*Acacia* aff. *subtiliformis, Indigofera* sp. Gilesii (M.E. Trudgen 15869)*, Rhagodia* sp. Hamersley (M. Trudgen 17794), *Sida* sp. Barlee Range (S. van Leeuwen 1642), *Themeda* sp. Hamersley Station (M.E. Trudgen 11431) and *Triodia* sp. Mt Ella (M.E. Trudgen 12739) and one Priority 4 species (*Goodenia nuda*). Seven of these have been previously recorded by RT (but not by the DEC) within the Study Area. Table 6.2 summarises the known distribution and abundance of these taxa from all sources, including DEC records. Based on current records of the Western Australian Herbarium (Florabase), of the 13 species recorded within Greater West Angelas, five are not represented within the conservation estate (*Aristida jerichoensis* var. *subspinulifera*, *Brachyscome* sp. Wanna Munna Flats (S. van Leeuwen 4662), *Brunonia* sp. long hairs (D.E. Symon 2440), *Indigofera* sp. Gilesii (M.E. Trudgen 15869) and *Triodia* sp. Mt Ella (M.E. Trudgen 12739). It is possible that future studies in conservation reserves may result in the discovery of these taxa within their boundaries, but as this is not a certainty, these taxa are considered more vulnerable to mining activities, as there is no locality in which a representative population of the species can be preserved.

*Aristida jerichoensis* var. *subspinulifera* is a Priority One taxon with six known locations within the Pilbara bioregion. It was collected within the West Angelas Study Area, with an estimated 1948 individuals from 44 locations. Previous records for this taxon indicate that it can become locally common in preferred habitat, which is present within hardpan sandplains within the Study Area.

*Brunonia* sp. long hairs (D.E. Symon 2440), Priority One, was collected from 10 locations in the current survey, with 20 individuals recorded. It tends to occur as scattered individuals growing on floodplains and rangelands in red sandy-clay soils. *Brunonia* sp. long hairs is taxonomically similar to *Brunonia australis sensu lato*, which is a phenotypically plastic species occurring in a wide variety of environments across Australia, and is highly variable with respect to the degree of hairiness (Carolin 1992). Current advice form the Western Australian Herbarium is that the two are likely to be amalgamated in the future (Hislop 2012, *pers. comm.*), but as this change has not yet been adopted by the Western Australian Herbarium, *Brunonia* sp. long hairs is considered distinct and regarded as Priorty Flora species for in this study.

Records of two taxa represent significant range extensions; *Corymbia zygophylla* and *Euphorbia schultzii*. These range extensions may reflect the boundary of the species habitat, but are also likely to result from a lack of collection and/or lodgement. One other taxon has been recorded for the first time in the Pilbara Bioregion: *Maireana lanosa*. It is not considered a significant range extension as it does not exceed 100 km in distance from a known record; but it expands the population occurrence in terms of regional distribution.

**Table 6.2 – Regional Distribution of Priority Flora Recorded during the Current Survey**

| Species | Status | RT Locations in Study Area | *ecologia* Locations in Study Area | Number of Individuals Recorded | Florabase (regional) records | Bioregions of occurrence | Records within Conservation Estates | Recorded abundance elsewhere |
|---|---|---|---|---|---|---|---|---|
| *Lepidium catapycnon* | T | 0 | 4 | 29 | 14 | Pilbara | 1 | Isolated populations |
| *Aristida jerichoensis* var. *subspinulifera* | P1 | 0 | 44 | 1948 | 6 | Pilbara | 0 | Locally common |
| *Brachyscome* sp. Wanna Munna Flats (S. van Leeuwen 4662) | P1 | 0 | 2 | 2 | 10 | Gascoyne, Pilbara | 0 | Uncommon |
| *Brunonia* sp. long hairs (D.E. Symon 2440) | P1 | 0 | 10 | 20 | 3 | Central Ranges, Pilbara | 0 | Uncommon |
| *Aristida lazaridis* | P2 | 1 | 3 | 23 | 3 | Pilbara | 1 | Rare |
| *Eremophila forrestii* subsp. Pingandy (M.E. Trudgen 2662) | P2 | 1 | 1 | 1 | 4 | Pilbara | 3 | Common |
| *Acacia* aff. *subtiliformis* | P3 | 0 | 3 | 250 | 11 | Pilbara | 1 | Locally abundant |
| *Indigofera* sp. Gilesii (M.E. Trudgen 15869) | P3 | 37 | 23 | 232 | 16 | Central Ranges, Pilbara, Tanami | 0 | Common |
| *Rhagodia* sp. Hamersley (M. Trudgen 17794) | P3 | 7 | 31 | 81 | 23 | Gascoyne, Pilbara | 2 | Common |
| *Sida* sp. Barlee Range (S. van Leeuwen 1642) | P3 | 6 | 7 | 42 | 30 | Gascoyne, Pilbara | 5 | Locally Common |
| *Themeda* sp. Hamersley Station (M.E. Trudgen 11431) | P3 | 3 | 7 | 3505 | 20 | Pilbara | 1 | Locally Uncommon |
| *Triodia* sp. Mt Ella (M.E. Trudgen 12739) | P3 | 39 | 9 | 300 | 14 | Pilbara | 0 | Locally Common |
| *Goodenia nuda* | P4 | 0 | 2 | 2 | 37 | Gascoyne, Pilbara | 1 | Locally Common |

## 6.2 VEGETATION OF CONSERVATION SIGNIFICANCE

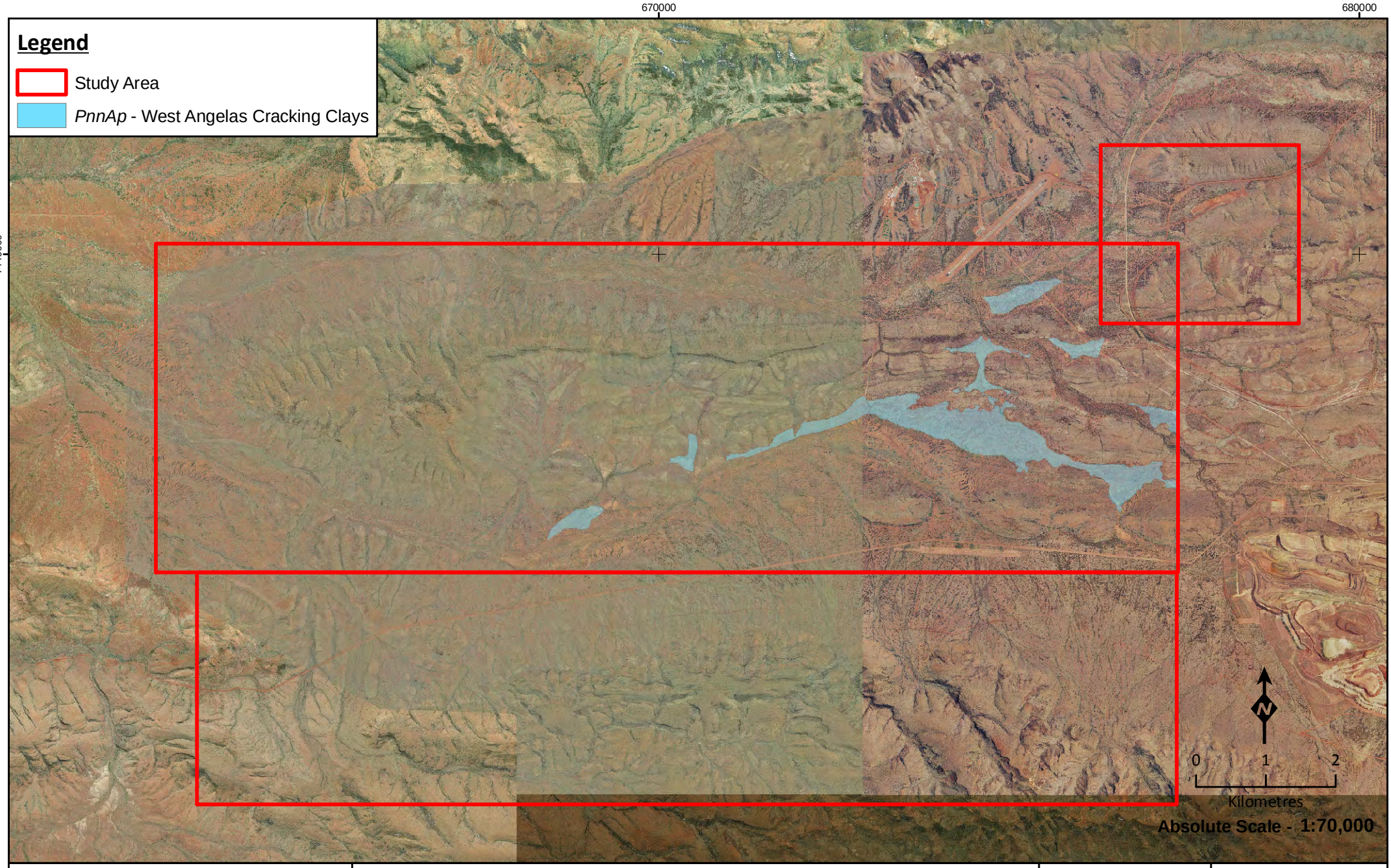
### 6.2.1 Vegetation of National Significance

National significance refers to those features of the environment which are recognised under legislation as being of importance to the Australian community. TECs listed under the EPBC Act are regarded as nationally significant. Currently, there are no nationally-listed TECs that occur within 40 km of the Study Area.

### 6.2.2 Vegetation of State Significance

State significance refers to those features of the environment that are recognised under State legislation as being of importance to the Western Australian community, in particular, communities listed as TECs or PECs. 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 PECs.

One Priority 1 PEC; West Angelas Cracking-Clays, occurs extensively within the Study Area (Figure 2.7). This portion of the Study Area was relatively accessible and no new areas of this community were observed outside of previously defined locations. The biggest threat to this PEC is from mining activities and associated infrastructure (Kendrick 2001). In this survey it was identified as vegetation unit *AlAp* (*Aristida latifolia, Astrebla pectinata* and *Brachyachne convergens* tussock grassland with isolated *Salsola australis, Boerhavia paludosa* and *Ptilotus nobilis* subsp. *nobilis* forbs) and covers an area of 302.23 ha (Figure 6.1). The PEC is officially described by the DEC as "open tussock grasslands of *Astrebla pectinata*, *A. elymoides*, *Aristida latifolia*, in combination with *Astrebla squarrosa* and low scattered shrubs of *Sida fibulifera*, on basalt derived cracking-clay loam depressions and flowlines". The vegetation unit *AlAp* shares the dominant grasses of *Aristida latifolia* and *Astrebla pectinata*, but the remaining species typical of the PEC were not present as dominants. However, *Sida fibulifera* was recorded in five of the seven quadrats of this vegetation type, although not in high abundances. *Astrebla elymoides* was not recorded at all within the study area. This species is known to occur in the West Angelas PEC but is difficult to identify later in the season when tussock grass heads have dicintergrated. Specifically for tussock grassland communties the survey timing may not have been optimal.

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# Distribution of PEC Unit *PnnAp* within the Greater West Angelas Study Area

**Figure: 6.1**
**Project ID: 1457**

**Drawn: CP**
**Date: 23/11/2012**

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

Unique Map ID: CP173

**A4**

Assessment of the significance at a state level of the vegetation of the Study Area is constrained by the lack of mapping across the state at a scale comparable to the mapping conducted during the current survey. The only source of vegetation mapping available across the state is that conducted by Beard (and in some instances co-authors) at a scale of 1:1,000,000. Beard attempted to map the vegetation as it would have been prior to European settlement (Beard 1976). Subsequently this dataset has been digitised and reinterpreted by the Department of Agriculture and Food to provide an estimate of current representations of these vegetation units (Shepherd *et al*. 2001). The spatial data provides an insight into the loss of vegetation as a result of settlement, its preservation within the conservation estate and its natural abundance. It has been used in the evaluation of conservation priorities for vegetation by the Northern Agricultural Region Native Vegetation Management Plan (Department of Environment and Conservation 2008), the Australian National Resources Atlas Biodiversity Assessment (Department of Sustainability Environment Water Population and Communities 2009) and the Biodiversity Audit of Western Australia (Department of Conservation and Land Management 2003).

Table 6.3 details the extent of these units within the Study Area, State and within land managed by the DEC. Table 6.3 shows that units 18 and 82 occur extensively and are relatively well represented within the conservation estate. The combined area of units 18 and 82 within the Study Area is <0.5% of their total representation and therefore the vegetation is well represented outside of the Study Area.

**Table 6.3 – Representation of Shepherd Vegetation Units Within the State and Study Area**

| Shepherd/Beard Units | | Area* in Western Australia ($km^2$) | Conservation Reserves | | Representation Within the Study Area | |
|---|---|---|---|---|---|---|
| No. | Beard Description | | Total Area Within DEC Managed Lands** ($km^2$) | Total Extent within Cons. Reserves (%) | Extent* ($km^2$) | Total Extent Within Study Area (%) |
| 18 | *Acacia* open shrubland / Ptilotus mixed open forbland | 199,807.3 | 12,440.8 | 6.2 | 89.7 | 0.04 |
| 82 | Hummock grasslands, low tree steppe; snappy gum over *Triodia wiseana* | 25,655.7 | 2,692.1 | 10.5 | 85.9 | 0.33 |

*The current Native Vegetation Extent dataset may contain some polygon errors such as overlaps (Department of Agriculture and Food).

** DEC Managed Lands as at June 2009

Vegetation is of conservation significance if it has "a role as a key habitat for threatened species" (EPA 2004, page 30). In this context the degree to which Priority taxa were localised to particular vegetation units was also assessed (Table 6.4).

*Lepidium catapycnon* (T) appears to have a high specificity to the vegetation unit *SggIrTw,* rocky hillslopes, accounting for 100% of all plants recorded. The vegetation unit *SggIrTw* is widespread in the study area (1,045 ha), and it is likely that the threatened species occurs in a particular habitat within the community. Nonetheless, this unit is significant due to the rarity of the species it supports. Similarly, *Aristida jerichoensis* var. *subspinulifera* (P1), although being present within 10 vegetation units, demonstrates a higher specificity to unit *AaTp* (sandy undulating plains) with 40.9% of locations and 57.9% of individuals recorded within this unit. *Indigofera* sp. Gilesii (M.E. Trudgen 15869) demonstrates specificity for the vegetation unit *SggTp,* rocky midslopes, with 47.8% of all locations and 31.9% of individuals recorded in this unit. *Sida* sp. Barlee Range (S. van Leeuwen 1642) favoured vegetation unit *AaPoTp,* which is only found in gullies and gorges, with 42.9% of the locations recorded in this unit.

Vegetation units *SggIrTw* (rocky hilltops) and *AaEcTp* (sandy plains) support five individual threatened and/or priority taxa. Collectively, these units account for eight out of the 13 Threatened and Priority Flora recorded in the survey: *Aristida jerichoensis* var. *subspinulifera*, *Brachyscome* sp. Wanna Munna Flats, *Brunonia* sp. long hairs, *Goodenia nuda, Indigofera* sp. Gilesii (M.E. Trudgen 15869), *Lepidium catapycnon*, *Rhagodia* sp. Hamersley and *Sida* sp. Barlee Range.

**Table 6.4 – Assessment of Specificity of Priority Taxa to West Angelas Vegetation**

| Taxon | Status | Vegetation Unit | Records | | Individuals | |
|---|---|---|---|---|---|---|
| | | | Count | % | Count | % |
| *Lepidium catapycnon* | T | *SggIrTw* | 4 | 1.0 | 29 | 1.0 |
| *Aristida jerichoensis* var. *subspinulifera* | P1 | *AaAc* | 5 | 11.4 | 201 | 10.1 |
| | | *AaSaoTp* | 2 | 4.5 | 15 | 0.8 |
| | | *AaTssp* | 1 | 2.3 | 5 | 0.3 |
| | | *AaTp* | 18 | 40.9 | 1155 | 57.9 |
| | | *AaEcTp* | 1 | 2.3 | 5 | 0.3 |
| | | *AaTb* | 1 | 2.3 | 50 | 2.5 |
| | | *EgSggTb* | 4 | 9.1 | 66 | 3.3 |
| | | *AaTt* | 1 | 2.3 | 10 | 0.5 |
| | | *PsTp* | 10 | 22.7 | 486 | 24.4 |
| | | *SggIrTw* | 1 | 2.3 | 1 | 0.1 |
| *Brachyscome* sp. Wanna Munna Flats (S. van Leeuwen 4662) PN | P1 | *AaEcTp* | 1 | 0.5 | 1 | 0.3 |
| | | *PsTp* | 1 | 0.5 | 2 | 0.7 |
| *Brunonia* sp. long hairs (D.E. Symon 2440) | P1 | *AaAc* | 1 | 10.0 | 5 | 13.9 |
| | | *AaTp* | 1 | 10.0 | 2 | 5.6 |
| | | *EllSggTw* | 1 | 10.0 | 2 | 5.6 |
| | | *AaEcTp* | 4 | 40.0 | 9 | 25.0 |
| | | *ApTssp* | 1 | 10.0 | 15 | 41.7 |
| | | *EllSggTp* | 1 | 10.0 | 2 | 5.6 |
| | | *SggAbTp* | 1 | 10.0 | 1 | 2.8 |
| *Aristida lazaridis* | P2 | *AaTp* | 1 | 33.3 | 20 | 74.1 |
| | | *AaTt* | 1 | 33.3 | 5 | 18.5 |
| | | *PsTp* | 1 | 33.3 | 2 | 7.4 |
| *Eremophila forrestii* subsp. Pingandy (M.E. Trudgen 2662) | P2 | *AaTssp* | 1 | 100.0 | 1 | 100.0 |
| *Acacia* aff. *subtiliformis* | P3 | *EllSggTw* | 3 | 100.0 | 250 | 100.0 |
| *Indigofera* sp. Gilesii (M.E. Trudgen 15869) | P3 | *AaPoTp* | 3 | 13.0 | 15 | 5.4 |
| | | *ElAmTssp* | 2 | 8.7 | 27 | 9.7 |
| | | *SggTp* | 11 | 47.8 | 89 | 31.9 |
| | | *EgSggTp* | 4 | 17.4 | 45 | 16.1 |
| | | *SggAbTp* | 1 | 4.3 | 2 | 0.7 |
| | | *SggIrTw* | 2 | 8.7 | 101 | 36.2 |
| *Rhagodia* sp. Hamersley (M. Trudgen 17794) | P3 | *AaAc* | 3 | 9.7 | 9 | 9.4 |
| | | *AaEffTp* | 1 | 3.2 | 5 | 5.2 |
| | | *AaSaoTp* | 2 | 6.5 | 6 | 6.3 |
| | | *AaTp* | 6 | 19.4 | 13 | 13.5 |
| | | *EllSggTw* | 2 | 6.5 | 4 | 4.2 |
| | | *AaEcTp* | 2 | 6.5 | 8 | 8.3 |
| | | *PsTp* | 8 | 25.8 | 29 | 30.2 |
| | | *SggAbTp* | 1 | 3.2 | 2 | 2.1 |
| | | *SggIrTw* | 6 | 19.4 | 20 | 20.8 |
| *Sida* sp. Barlee Range (S. van Leeuwen 1642) | P3 | *AaPoTp* | 3 | 42.9 | 18 | 33.3 |
| | | *EllSggTp* | 2 | 28.6 | 2 | 3.7 |
| | | *SggIrTw* | 2 | 28.6 | 34 | 63.0 |
| *Themeda* sp. Hamersley Station (M.E. Trudgen 11431) PN | P3 | *AaTssp* | 1 | 14.3 | 1000 | 28.3 |
| | | *EllSggTw* | 1 | 14.3 | 500 | 14.1 |
| | | *AlAp* | 5 | 71.4 | 2035 | 57.6 |
| *Triodia* sp. Mt Ella (M.E. Trudgen | P3 | *AaPoTp* | 2 | 25.0 | 105 | 31.2 |

| Taxon | Status | Vegetation Unit | Records | | Individuals | |
|---|---|---|---|---|---|---|
| | | | Count | % | Count | % |
| 12739) | | *Tp* | 2 | 25.0 | 82 | 24.3 |
| | | *ElAmTssp* | 3 | 37.5 | 120 | 35.6 |
| | | *SggTp* | 1 | 12.5 | 30 | 8.9 |
| *Goodenia nuda* | P4 | *AaEcTp* | 1 | 50.0 | 5 | 71.4 |
| | | *AaTb* | 1 | 50.0 | 2 | 28.6 |

### 6.2.3 Vegetation of Regional Significance

The regional inventory of the Pilbara Rangelands undertaken by Van Vreeswyk *et al.* (2004) and the Ashburton Rangelands surveyed by Payne *et al* (1982) provides some insight into the distribution of broad scale vegetation in a regional context. Of the seven land systems recorded within the Study Area, no single system represents more than one percent of the total land system mapped in the PIR and AIR. This indicates that each land system is represented well in a regional context.

#### 6.2.3.1 Groundwater Dependent Ecosystems

Groundwater Dependent Ecosystems (GDEs) are defined by their dependence on groundwater for their continued survival. Dependence at any stage(s) during a lifecycle is considered sufficient to be defined as a GDE (Eamus 2009). Whilst some ecosystems may use groundwater reserves they may not be entirely dependent on them and hence are not defined as a GDE.

Of the four known types of GDEs described by Hatton *et al* (1998) (Terrestrial vegetation, River base flow systems, Wetlands and Aquifer/Cave ecosystems), only River base flow systems are present within the West Angelas Study Area. These ecosystems are characterised by the presence of species that have been found to rely on groundwater sources for water intake, known as phreatophytic species (Maunsell Australia 2006). Three species known to be phreatophytic are known to occur within the vicinity of the Study Area: *Eucalyptus camaldulensis* subsp. *refulgens*, *Melaleuca argentea* and *Eucalyptus victrix* (facultative phreatophyte). The degree to which *E. victrix* is an obligate phreatophyte is not well defined and may vary from location to location.

While *E. victrix* is the only phreatophytic species that was confirmed with reporoductive material within the West Angelas Study Area, *E. camaldulensis* is also known to be present along major drainage lines and is likely to occur within vegetation unit *AaPoTt*. This unit supports variable densities of *E. victrix* and therefore may be a vadophytic ecosystem (i.e. supporting plants that rely on moisture in the soil surface profile) or occasionally phreatophytic, and on this basis has been qualified as a potential GDE. Using the precautionary principles outlined in Position Statement 3, this vegetation unit is regarded as a potential GDE for this study. These vegetation units are localised to the Turee Creek area, which runs across the north of the Study Area (Figure 6.2).

#### 6.2.3.2 Sheet-Flow Dependent Vegetation

**Sheet-flow Dependent Vegetation**

Groved and banded mulga communities growing on relatively flat plains are widely recognised as being dependent on patterns of surface water flow. The term "mulga" describes a group of *Acacia* species that were previously referred to as varieties of *Acacia aneura*. The species currently in this group include: *Acacia aneura*, *A. aptaneura*, *A. caesaneura*, *A. fuscaneura*, *A. incurvaneura*, *A. macraneura*, *A. mulganeura* and *A. pteraneura*. The species within the mulga group are bushy shrubs

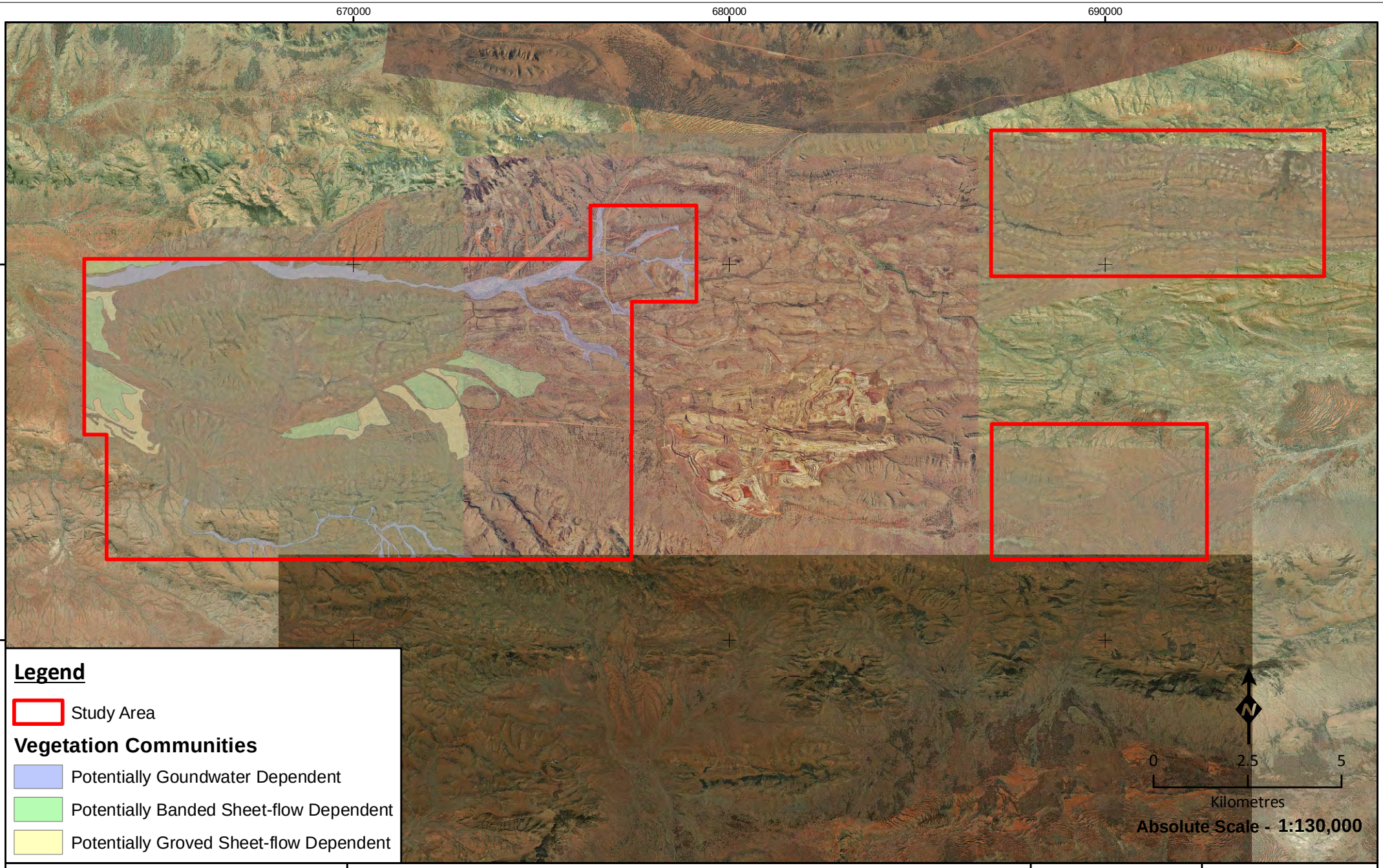
or trees ranging in height from 2-10 m, with considerable variation in growth form and phyllode morphology.

Sheet flows carry material (including seeds and other organic and inorganic debris) which is trapped by existing vegetation. his leads to the formation of a mosaic pattern of groves and banded vegetation with relatively bare areas in between. Thus the development and retention of mulga groves is directly dependent upon sheet flow. The different forms of Mulga (banded or groved) result from the position within the landscape and the availability of sheet flows of surface water. It is therefore thought that the susceptibility to alterations in sheet flow may also differ between banded and groved Mulga. However, both forms are potentially affected when sheet flow is disrupted within a landscape (University of Western Australia 2010).

Mulga has a root system that is adapted for taking up water from thin surface soils and has adaptations that concentrate soil water near the plant and conserve water within the plant. Consequently, the distribution and abundance of mulga is particularly influenced by soil moisture and the pattern of surface drainage (Paczkowska and Chapman, 2000). Construction can have an impact on sheet flow by creating a barrier on flow that increases the quantity of water on one side and decreases it on the other, or diverts the flow to a different area. Alterations to sheet-flow are likely to be greater in close proximity to the construction, but estimating impact is speculative and requires hydrogeological modelling. Until the shadow effect of a proposed development can be determined and the impact adequately assessed, a precautionary approach should be taken.

The diversion of sheet flow or concentration of sheet flow to particular areas is likely to deprive or waterlog soils, with deleterious impacts on mulga. Hence areas with very shallow topography, which commonly support mulga, are likely to be more susceptible. The current analysis has identified banded or groved mulga communities on shallow topography as potentially Sheet Flow Dependent Vegetation (SDV).

The vegetation unit *AaEcTp* (*Acacia* open woodland over *Eremophila* isolated shrubs over *Triodia* open grassland) supports groved and banded mulga communities and is considered likely to be sheet-flow dependent. The distribution of this unit is detailed in Figure 6.2. Other vegetation communities described in this survey are characterised by mulga species, but due to the fact that the trees do not occur in groved or banded patterns, they have not been included in the mapping.

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# Sheet-flow and Groundwater Dependent Ecosystems of the West Angelas Study Area

**Figure: 6.2**
**Project ID: 1457**

**Drawn: CP**
**Date: 23/11/2012**

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

Unique Map ID: CP150

**A4**

### 6.2.4 Vegetation of Local Significance

In a local context, vegetation can be considered significant if it is locally uncommon or is associated with habitats of local significance. Vegetation of local significance is not legislatively protected but is of conservation value if areas are restricted and have not been identified to occur outside the Study Area. The least extensive vegetation units locally are *AaEffTp* (141.54 ha) and *AmTw* (108.7 ha), which represent 0.80 % and 0.62% of the Study Area, respectively (Table 6.5).

Vegetation which supports rare flora is also considered locally significant. Vegetation units *AaPoTp, AaTp, SggTp* and *SggIrTw* all support Priority or Threatened flora. In particular, vegetation units *SggIrTw* (rocky hilltops) and *AaEcTp* (sandy plains) support five individual threatened and/or priority taxa. Collectively these units account for eight out of the 13 threatened and priority flora recorded in the survey: *Aristida jerichoensis* var. *subspinulifera*, *Brachyscome* sp. Wanna Munna Flats, *Brunonia* sp. long hairs, *Goodenia nuda, Indigofera* sp. Gilesii (M.E. Trudgen 15869), *Lepidium catapycnon*, *Rhagodia* sp. Hamersley and *Sida* sp. Barlee Range.

**Table 6.5 – Local Extent of Vegetation Units within the West Angelas Study Area.**

| Unit | Landform | Vegetation Description | Area (ha) | % Total |
|---|---|---|---|---|
| *AaAc* | Floodplain/Drainage Line | *Acacia aptaneura* and *A. pruinocarpa* open woodland over *Aristida contorta* sparse tussock grassland over *Pterocaulon sphacelatum* and *Ptilotus nobilis* subsp. *nobilis* isolated forbs. | 505.39 | 2.87 |
| *AaEffTp* | Rocky Midslope | *Acacia aptaneura* and *A. pruinocarpa* open woodland over sparse *Eremophila fraseri* subsp. *fraseri* and *Acacia marramamba* sparse shrubland over *Triodia pungens* sparse hummock grassland. | 141.54 | 0.80 |
| *AaPoTp* | Gully | *Acacia aptaneura* open woodland over *Ptilotus obovatus* isolated shrubs over *Themeda triandra* and *Eriachne mucronata* open tussock grassland. | 319.01 | 1.81 |
| *AaPoTt* | Sandy Floodplain | *Acacia aptaneura* open woodland over *Ptilotus obovatus* sparse shrubland over *Themeda triandra* open tussock grassland. | 706.06 | 4.01 |
| *AaSaoTp* | Floodplain/Drainage Line | *Acacia aptaneura* and *A. ayersiana* open woodland over *Senna artemisioides* subsp. *oligophylla, S. glutinosa* subsp. *glutinosa* and *Eremophila forrestii* subsp. *forrestii* sparse shrubland over *Triodia pungens* open hummock grassland. | 447.27 | 2.54 |
| *AaTssp* | Rocky Footslope | *Acacia aptaneura* and *A. pruinocarpa* open woodland over *A. tetragonophylla, Senna glutinosa* subsp. *glutinosa* and *S. artemisioides* subsp. *oligophylla* isolated shrubs over *Triodia wiseana* and *T. pungens* open hummock grassland. | 927.28 | 5.27 |
| *AaTp* | Sandy Undulating Plain | *Acacia pruinocarpa, A. aptaneura* and *A. ayersiana* woodland over *Triodia pungens* open hummock grassland. | 982.26 | 5.58 |
| *Tp* | Rocky Midslope | *Eucalyptus leucophloia* subsp. *leucophloia* and *Acacia pruinocarpa* isolated trees over *Senna glutinosa* subsp. *glutinosa, A. bivenosa* and *Ptilotus rotundifolius* isolated shrubs over *Triodia pungens* or *T. basedowii* or *T.* sp. Mt Ella hummock grassland. | 975.86 | 5.55 |
| *AaTb* | Rocky Hilltop | *Acacia aptaneura* and *A. pruinocarpa* open woodland over *A. bivenosa* isolated shrubs *Triodia basedowii* and *T. pungens* open hummock grassland. | 1,227.4 | 6.98 |
| *EllSggTw* | Rocky Hilltop | *Eucalyptus leucophloia* subsp. *leucophloia* and *Acacia aptaneura* open woodland over *Senna glutinosa* subsp. *glutinosa* and *S. artemisioides* subsp. *oligophylla* open shrubland over *Triodia wiseana* or *T. pungens* open hummock grassland | 1,215.97 | 6.91 |
| *EllAmTssp* | Rocky Hilltop | *Eucalyptus leucophloia* subsp. *leucophloia* and *E. gamophylla* open woodland over *Acacia maitlandii, A. hamersleyensis, Keraudrenia velutina* and *Senna glutinosa* subsp. *glutinosa* open shrubland over *Triodia wiseana* and/or *T. pungens* and/or *T. basedowii* open hummock grassland. | 108.7 | 0.62 |
| *AmTw* | Sandy Plain/Riverbed | *Eucalyptus leucophloia* subsp. *leucophloia* isolated trees over *Acacia maitlandii* sparse shrubland over *Triodia wiseana* and *T. longiceps* hummock grassland. | 1,769.85 | 10.06 |
| *AaEcTp* | Rocky Midslope | *Acacia aptaneura* and *A. pruinocarpa* open woodland over *Eremophila caespitosa* and *Tribulus suberosus* isolated shrubs over *Triodia pungens* open hummock grassland | 292.18 | 1.66 |
| *ApTssp* | Gravely Plain | *Acacia pruinocarpa* and *Eucalyptus leucophloia* subsp. *leucophloia* open woodland over *Senna glutinosa* subsp. *glutinosa* and *A. maitlandii* isolated shrubs over *Triodia basedowii* or *T. pungens* or *T. wiseana* open hummock grassland. | , | 8.60 |
| *SggTp* | Rocky Midslope | *Eucalyptus leucophloia* subsp. *leucophloia* and *Corymbia hamersleyana* isolated trees over *Senna glutinosa* subsp. *glutinosa* and *Acacia maitlandii* sparse shrubland over *Triodia pungens* open hummock grassland. | 210.6 | 1.20 |
| *EgSggTb* | Floodplain/Drainage Line | *Eucalyptus gamophylla* and *Corymbia deserticola* subsp. *deserticola* open woodland over *Senna artemisioides* subsp. *oligophylla* and *Indigofera monophylla* sparse shrubland over *Triodia basedowii* and *T. pungens* open hummock grassland | 309.52 | 1.76 |
| *EllSggTp* | Rocky Hilltop | *Eucalyptus leucophloia* subsp. *leucophloia* and *Acacia marramambra* open woodland over *Senna glutinosa* subsp. | 2,491.87 | 14.16 |

| Unit | Landform | Vegetation Description | Area (ha) | % Total |
|---|---|---|---|---|
| | | *glutinosa* open shrubland over *Triodia pungens* open hummock grassland | | |
| *AaTt* | Sandy Floodplain | *Acacia aptaneura* and *Eucalyptus xerothermica* woodland over *Ptilotus obovatus* isolated shrubs over *Themeda triandra* open tussock grassland | 391.54 | 2.23 |
| *AlAp* | Sandy Plain | *Aristida latifolia, Astrebla pectinata* and *Brachyachne convergens* tussock grassland with isolated *Salsola australis, Boerhavia paludosa* and *Ptilotus nobilis* subsp. *nobilis* forbs | 302.23 | 1.72 |
| *PsTp* | Sandy Plain | *Acacia aptaneura* or *A. ayersiana* open woodland over *Pterocaulon sphacelatum* and *Dysphania kalparri* sparse forbland with *Triodia pungens* open hummock grassland | 174.39 | 0.99 |
| *SggAbTp* | Gravely Plain | *Acacia pruinocarpa* and *Eucalyptus leucophloia* subsp. *leucophloia* or *Corymbia hamersleyana* isolated trees over *Senna glutinosa* subsp. *glutinosa, Acacia bivenosa* and *Gossypium robinsonii* open shrubland over *Triodia pungens* hummock grassland | 1,539.18 | 8.75 |
| *SggIrTw* | Rocky Hilltop | *Acacia inaequilatera* isolated trees over *Senna glutinosa* subsp *glutinosa* and *Indigofera rugosa* open shrubland over *Triodia wiseana* hummock grassland | 1,045.87 | 5.94 |
| TOTAL | | | 17,596.58 | 100 |

Shading highlights vegetation units considered to be of local conservation significance due to their rarity.

Shading highlights vegetation units considered to be of local conservation significance due to specificity of rare flora.

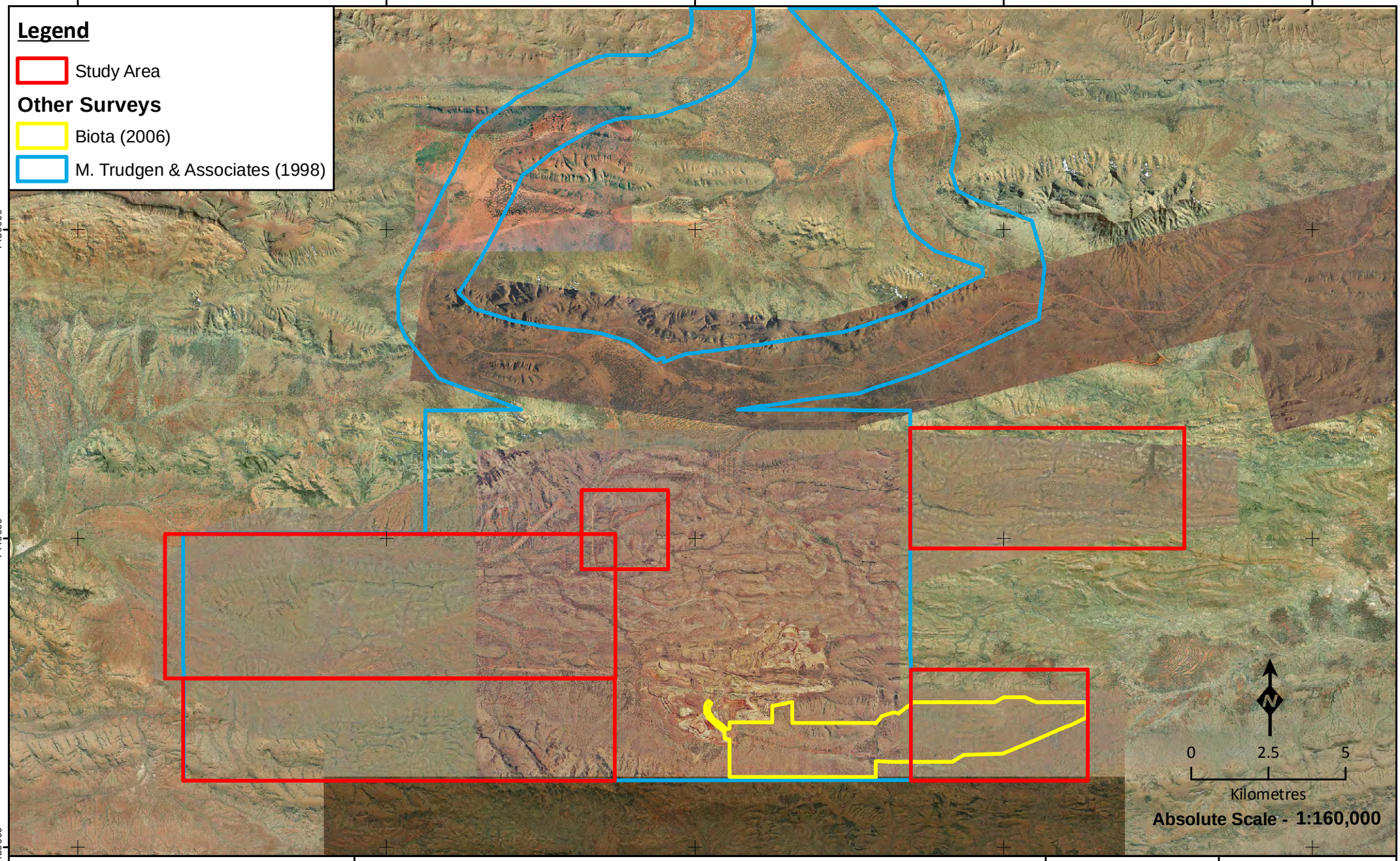
## 6.3 COMPARISON OF LOCAL VEGETATION COMMUNITIES

One hundred and fifty quadrats were used to define 22 vegetation units within the Study Area. All vegetation units from the ME Trudgen & Associates (1998), Biota (2006) and Biota (2010) surveys were compared with the current survey's data. The use of multivariate software SYSTAT™ was not possible in this instance as the species by site matrices were not available.

Vegetation communities were instead analysed by comparing the spatial data, vegetation descriptions and associated species to align the most similar units between each project. The species used to describe the vegetation units are paramount to the comparison, and it is possible, therefore, that the results drawn from this comparison would be different to results derived from species by site matrices data.

When vegetation units from the current survey (22 units from 150 quadrats) were compared to the ME Trudgen & Associates (1998) survey it was apparent that the quadrat density of the current survey allowed the majority of the vegetation to be mapped at a finer scale. Multiple vegetation units from the current survey were classified as the same under the broader units defined by ME Trudgen & Associates. The exception to this is the riverine/floodplain communities which were mapped at a finer scale by M. Trudgen & Associates when compared to the current survey. This is depicted in Table 6.6 where it can be seen that vegetation unit *AaPoTt* from the current survey is comparable to units 2cab, 2cac and 6/2ef from the ME Trudgen & Associates survey in the same area. The mapping boundaries of the ME Trudgen & Associates survey extended beyond that of the current survey resulting in just 29 of the 54 communities defined by ME Trudgen & Associates represented within the current Study Area. Table 6.6 depicts a comparison of units from each survey that are the most directly comparable, whilst also indicating regional distribution outside of the current Study Area.

Vegetation communities of the current survey were also co-analysed with units described in the 2006 Biota survey of Deposits E and F. The mapping of these two surveys was completed at a comparable scale and vegetation units corresponded well based on location, description and associated species as depicted in Table 6.7. Approximately 50% of the area surveyed by Biota falls outside of the current Study Area, although, of the 12 units described by Biota, 10 of the vegetation units identified in the current survey match well and are interpreted to be equivalent.




ecologia ENVIRONMENT

**Location of West Angelas, M. Trudgen & Associates (1998) and Biota (2006) Study Areas**

**Figure: 6.3**
**Project ID: 1457**

**Drawn: CP**
**Date: 23/11/2012**

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

Unique Map ID: CP151

**A4**

**Table 6.6 – Comparison of Trudgen & Associates Vegetation Units within the Study Area**

| *ecologia* 2012 Vegetation Units | | ME Trudgen & Associates (1998) Vegetation Units | | Area outside of Study Area (ha) |
|---|---|---|---|---|
| **Vegetation Unit** | **NVIS level VI Description** | **Vegetation Unit** | **NVIS level V Description** | |
| *AaAc* | *Acacia aptaneura* and *A. pruinocarpa* open woodland over *Aristida contorta* sparse tussock grassland over *Pterocaulon sphacelatum* and *Ptilotus nobilis* subsp. *nobilis* isolated forbs. | *6/2ef* | *Eucalyptus victrix* open woodland over *Acacia aneura* var. *longicarpa* scattered tall shrubs over *Enneapogon* sp. and *Eriachne benthamii* tussock grassland over *Eragrostis pergracilis* and *Aristida contorta* | 978.55 |
| | | *6adb215* | *Aristida contorta* open annual tussock grassland | 17.39 |
| *AaPoTp* | *Acacia aptaneura* and *A. pruinocarpa* open woodland over sparse *Eremophila fraseri* subsp. *fraseri* and *Acacia marramamba* sparse shrubland over *Triodia pungens* sparse hummock grassland. | *5edaf* | *Acacia aneura* var. *longicarpa* and *Acacia rhondophloia* high shrubland over *Eremophila fraseri* ssp. *fraseri*, *Eremophila lachnocalyx* and *Eremophila exilifolia* shrubland over *Triodia pungens* open hummock grassland | 0.00 |
| *AaPoTt* | *Acacia aptaneura* open woodland over *Ptilotus obovatus* isolated shrubs over *Themeda triandra* and *Eriachne mucronata* open tussock grassland. | *2cab* | *Eucalyptus xerothermica* low open woodland over *Acacia pruinocarpa* scattered tall shrubs over *Maireana* spp. Scattered low shrubs over *Triodia pungens* open hummock grassland with *Themeda triandra* scattered tussock grass | 81.79 |
| | | *2cac* | *Eucalyptus xerothermica* scattered low trees over *Acacia aneura* var. *longicarpa* and *Acacia* aff. *aneura* high shrubland over *Themeda triandra* and *Chrysopogon fallax* very open tussock grassland with *Triodia pungens* and *Triodia wiseana* scattered hummock grass | 879.89 |
| | | *6/2ef* | *Eucalyptus victrix* open woodland over *Acacia aneura* var. *longicarpa* scattered tall shrubs over *Enneapogon* sp. and *Eriachne benthamii* tussock grassland over *Eragrostis pergracilis* and *Aristida contorta* | 978.55 |
| *AaSaoTp* | *Acacia aptaneura* and *A. ayersiana* open woodland over *Senna artemisioides* subsp. *oligophylla, S. glutinosa* subsp. *glutinosa* and *Eremophila forrestii* subsp. *forrestii* sparse shrubland over *Triodia pungens* open hummock grassland. | *5edacl* | *Eucalyptus gamophylla* scattered low trees over *Acacia bivenosa* and *Acacia pyrifolia* scattered tall shrubs over *Triodia pungens* and *Triodia longiceps* open hummock grassland | 288.48 |
| *AaTssp* | *Acacia aptaneura* and *A. pruinocarpa* open woodland over *A. tetragonophylla, Senna glutinosa* subsp. *glutinosa* and *S. artemisioides* subsp. *oligophylla* isolated shrubs over *Triodia wiseana* and *T. pungens* open hummock grassland. | *5edb* | *Acacia ayersiana*, *Acacia* aff. *aneura* (narrow green), *Acacia* Aff. *catenulata*, *Acacia* aff. *aneura* (grey, bushy form) and *Acacia* aff. *aneura* (scythe-shaped) high open shrubland over *Maireana* spp. low scattered shrubs over *Triodia pungens* very open hummock grassland | 2,762.56 |
| *AaTp* | *Acacia pruinocarpa, A. aptaneura* and *A. ayersiana* woodland over *Triodia pungens* open hummock grassland. | *6adb26* | *Acacia* aff. *aneura* (scythe-shaped; MET 15,743), *A. pruinocarpa* scattered tall shrubs over *Triodia pungens* open hummock grassland with *Themeda triandra* scattered tussock grasses | 231.33 |

| *ecologia* 2012 Vegetation Units | | ME Trudgen & Associates (1998) Vegetation Units | | Area outside of Study Area (ha) |
|---|---|---|---|---|
| **Vegetation Unit** | **NVIS level VI Description** | **Vegetation Unit** | **NVIS level V Description** | |
| | | *6adb213* | *Acacia* aff. *aneura* (scythe-shaped; MET 15,743), *A. pruinocarpa*, A. aff. *aneura* (grey, bushy form; MET 15,732 high shrubland over *Eremophila forrestii* subsp. *forrestii* scattered shrubs over *Triodia pungens* very open hummock grassland | 246.47 |
| *Tp* | *Eucalyptus leucophloia* subsp. *leucophloia* and *Acacia pruinocarpa* isolated trees over *Senna glutinosa* subsp. *glutinosa, A. bivenosa* and *Ptilotus rotundifolius* isolated shrubs over *Triodia pungens* or *T. basedowii* or *T.* sp. Mt Ella hummock grassland. | *5edae* | *Scaervola acacioides* open shrubland over *Triodia pungens* open hummock grassland | 108.22 |
| *EllSggTw* | *Eucalyptus leucophloia* subsp. *leucophloia* and *Acacia aptaneura* open woodland over *Senna glutinosa* subsp. *glutinosa* and *S. artemisioides* subsp. *oligophylla* open shrubland over *Triodia wiseana* or *T. pungens* open hummock grassland | *8bj* | *Acacia aneura* var. *longicarpa* and *Acacia pruinocarpa* high open shrubland over *Acacia pyrifolia* and cassia *oligophylla* scattered shrubs over *Triodia wiseana* and *Triodia pungens* open hummock grassland | 2,875.92 |
| *EllAmTssp* | *Eucalyptus leucophloia* subsp. *leucophloia* and *E. gamophylla* open woodland over *Acacia maitlandii, A. hamersleyensis, Keraudrenia velutina* and *Senna glutinosa* subsp. *glutinosa* open shrubland over *Triodia wiseana* and/or *T. pungens* and/or *T. basedowii* open hummock grassland. | *5kdm1* | *Eucalyptus leucophloia* scattered low trees over *Triodia* aff. *basedowii* and *Triodia pungens* open hummock grassland | 2,582.85 |
| | | *5kdm2* | *Eucalyptus leucophloia* and *Corymbia hamersleyana* low open woodland over *Acacia maitlandii* scattered shrubs over *Triodia wiseana* open hummock grassland | 1,147.37 |
| | | *5edac* | *Eucalyptus gamophylla* scattered low trees over *Acacia bivenosa*, A. pyrifolia scattered tall shrubs over *Triodia pungens* open hummock grassland | 3.35 |
| *AaEcTp* | *Acacia aptaneura* and *A. pruinocarpa* open woodland over *Eremophila caespitosa* and *Tribulus suberosus* isolated shrubs over *Triodia pungens* open hummock grassland | *6adb26* | *Acacia* aff. *aneura* and *Acacia pruinocarpa* scattered tall trees over *Maireana* spp. scattered low shrubs over *Triodia pungens* open hummock grassland with *Themeda triandra* scattered tussock grass | 231.33 |
| *AaTb* | *Acacia aptaneura* and *A. pruinocarpa* open woodland over *A. bivenosa* isolated shrubs *Triodia basedowii* and *T. pungens* open hummock grassland. | *6adb232* | *Acacia aneura* var. *longicarpa* high shrubland over *Rhagodia* sp. Hamersley, *Ptilotus obovatus* open shrubland over *Digitaria brownii* scattered tussock grassland | 201.59 |
| *SggTp* | *Eucalyptus leucophloia* subsp. *leucophloia* and *Corymbia hamersleyana* isolated trees over *Senna glutinosa* subsp. *glutinosa* and *Acacia maitlandii* sparse shrubland over *Triodia pungens* open hummock grassland. | *5kdm3* | *Eucalyptus leucophloia* scattered low trees over *Acacia pruinocarpa* scattered tall shrubs over *Triodia pungens* open hummock grassland | 209.82 |

| *ecologia* 2012 Vegetation Units | | ME Trudgen & Associates (1998) Vegetation Units | | Area outside of Study Area (ha) |
|---|---|---|---|---|
| **Vegetation Unit** | **NVIS level VI Description** | **Vegetation Unit** | **NVIS level V Description** | |
| *EgSggTb* | *Eucalyptus gamophylla* and *Corymbia deserticola* subsp. *deserticola* open woodland over *Senna artemisioides* subsp. *oligophylla* and *Indigofera monophylla* sparse shrubland over *Triodia basedowii* and *T. pungens* open hummock grassland | *5eda* | *Corymbia deserticola* scattered low trees over *Acacia bivenosa*, *Acacia pruinocarpa* and *Hakea chordophylla* scattered tall shrubs over *Cassia prunosa* scattered shrubs over *Triodia* aff. *basedowii* and *Triodia pungens* open hummock grassland | 1,898.14 |
| *SggAbTp* | *Acacia pruinocarpa* and *Eucalyptus leucophloia* subsp. *leucophloia* or *Corymbia hamersleyana* isolated trees over *Senna glutinosa* subsp. *glutinosa, Acacia bivenosa* and *Gossypium robinsonii* open shrubland over *Triodia pungens* hummock grassland | | | |
| *EllSggTp* | *Eucalyptus leucophloia* subsp. *leucophloia* and *Acacia marramambra* open woodland over *Senna glutinosa* subsp. *glutinosa* open shrubland over *Triodia pungens* open hummock grassland | *5edad* | *Eucalyptus leucophloia* low open woodland over *Acacia* aff. *aneura*, *Acacia pruinocarpa* and *Acacia aneura* var. ?*aneura* open scrub over *Eremophila lachnocalyx* scattered shrubs over *Triodia pungens* open hummock grassland | 199.33 |
| | | *5kd3r* | *Eucalyptus leucophloia* low open woodland over *Acacia pruinocarpa* scattered tall shrubs over *Triodia pungens* open hummock grassland. | 0.00 |
| *AlAp* | *Aristida latifolia, Astrebla pectinata* and *Brachyachne convergens* tussock grassland with isolated *Salsola australis, Boerhavia paludosa* and *Ptilotus nobilis* subsp. *nobilis* forbs | *8db/8dc* | *Astrebla pectinata*, *Astrebla elymoides* and *Aristida latifolia* open tussock grassland | 166.06 |
| | | *8dd* | *Sida fibulifera* low scattered shrubs over *Astrebla squarrosa* tussock grassland | 0.00 |

Note: Comparisons are based on aerial imagery and vegetation descriptions. Species by site matrices were not available for data comparison.

**Table 6.7 – Comparison of Biota (2006) Vegetation Units within the Study Area**

| Ecologia 2012 Vegetation Units | | Biota (2006) Vegetation Units | | Area out side of Study Area (ha) |
|---|---|---|---|---|
| **Vegetation Unit** | **NVIS level VI Description** | **Vegetation Unit** | **NVIS level V Description** | |
| *SggAbTp* | *Acacia pruinocarpa* and *Eucalyptus leucophloia* subsp. *leucophloia* or *Corymbia hamersleyana* isolated trees over *Senna glutinosa* subsp. *glutinosa, Acacia bivenosa* and *Gossypium robinsonii* open shrubland over *Triodia pungens* hummock grassland | *C1* | *Eucalyptus* spp. scattered low trees over *Acacia maitlandii*, *Gossypium robinsonii*, *Petalostylis labicheoides* shrubland over *Triodia pungens* open hummock grassland and *Eriachne mucronata*, *Themeda triandra* open tussock grassland | 15.97 |
| *AaTt* | *Acacia aptaneura* and *Eucalyptus xerothermica* woodland over *Ptilotus obovatus* isolated shrubs over *Themeda triandra* open tussock grassland | *C2* | *Eucalyptus xerothermica* low open woodland over *Acacia maitlandii*, *Petalostylis labicheoides*, *Rulingia luteiflora* shrubland to tall shrubland over *Triodia pungens* open hummock grassland | 14.86 |
| *EllAmTssp* | *Eucalyptus leucophloia* subsp. *leucophloia* and *E. gamophylla* open woodland over *Acacia maitlandii, A. hamersleyensis, Keraudrenia velutina* and *Senna glutinosa* subsp. *glutinosa* open shrubland over *Triodia wiseana* and/or *T. pungens* and/or *T. basedowii* open hummock grassland. | *H1* | *Eucalyptus leucophloia* low open woodland over *Acacia maitlandii*, A. *hamersleyensis* shrubland over *Triodia pungens* (T. wiseana) mid-dense hummock grassland | 210.12 |
| *SggTp* | *Eucalyptus leucophloia* subsp. *leucophloia* and *Corymbia hamersleyana* isolated trees over *Senna glutinosa* subsp. *glutinosa* and *Acacia maitlandii* sparse shrubland over *Triodia pungens* open hummock grassland. | *H2* | *Acacia catenulata* low woodland over *Triodia pungens* mid-dense hummock grassland | 0.00 |
| *Tp* | *Eucalyptus leucophloia* subsp. *leucophloia* and *Acacia pruinocarpa* isolated trees over *Senna glutinosa* subsp. *glutinosa, A. bivenosa* and *Ptilotus rotundifolius* isolated shrubs over *Triodia pungens* or *T. basedowii* or *T.* sp. Mt Ella hummock grassland. | *H3* | *Corymbia ferriticola*, *Eucalyptus leucophloia* low open woodland over *Triodia* sp. Mt Ella, *T. pungens* hummock grassland and *Eriachne mucronata* open tussock grassland | 33.43 |
| *EllAmTssp* | *Eucalyptus leucophloia* subsp. *leucophloia* and *E. gamophylla* open woodland over *Acacia maitlandii, A. hamersleyensis, Keraudrenia velutina* and *Senna glutinosa* subsp. *glutinosa* open shrubland over *Triodia wiseana* and/or *T. pungens* and/or *T. basedowii* open hummock grassland. | *H4* | *Eucalyptus leucophloia* low open woodland over *Triodia wiseana* midd-dense hummock grassland and *Themeda triandra* tussock grassland | 0.00 |
| | | *H5* | *Eucalyptus gamophylla* low woodland over *Triodia* aff. *basedowii* (*T. pungens*) mid-dense hummock grassland | 415.33 |
| *AaTp* | *Acacia pruinocarpa, A. aptaneura* and *A. ayersiana* woodland over *Triodia pungens* open hummock grassland. | *M1* | *Acacia aneura* low open woodland over *Acacia bivenosa*, *Gossypium robinsonii*, *Sida* aff. *cardiophylla*, Scaevola parvifolia shrubland to low open shrubland over *Triodia* pungens, *T. schinzii* mid-dense hummock grassland | 98.62 |

| Ecologia 2012 Vegetation Units | | Biota (2006) Vegetation Units | | Area out side of Study Area (ha) |
|---|---|---|---|---|
| **Vegetation Unit** | **NVIS level VI Description** | **Vegetation Unit** | **NVIS level V Description** | |
| *AaTb* | *Acacia aptaneura* and *A. pruinocarpa* open woodland over *A. bivenosa* isolated shrubs *Triodia basedowii* and *T. pungens* open hummock grassland. | *M2* | *Acacia aneura* low open woodland over *Triodia* pungens, *T.* aff. *basedowii* mid-dense hummock grassland | 23.63 |
| | | *M5* | *Acacia aneura* low closed forest over *Triodia pungens* mid-dense hummock grassland | 0.00 |
| *PsTp* | *Acacia aptaneura* or *A. ayersiana* open woodland over *Pterocaulon sphacelatum* and *Dysphania kalparri* sparse forbland with *Triodia pungens* open hummock grassland | *M3* | *Acacia aneura* woodland over *Maireana* villosa, *Ptilotus obovatus*, *Rhagodia* sp. Hamersley open to low open shrubland over *Triodia* sp. Mt Ella open hummock grassland | 32.00 |
| *AaAc* | *Acacia aptaneura* and *A. pruinocarpa* open woodland over *Aristida contorta* sparse tussock grassland over *Pterocaulon sphacelatum* and *Ptilotus nobilis* subsp. *nobilis* isolated forbs. | *M4* | *Acacia aneura*, *A. pruinocarpa* low closed forest to low woodland over *Eremophila forrestii*, *E. longifolia*, *Ptilotus obovatus*, *Rhagodia* sp. Hamersley low open shrubland to open shrubland over *Triodia pungens* open hummock grassland | 223.85 |

Note: Comparisons are based on aerial imagery and vegetation descriptions. Species by site matrices were not available for data comparison

## 6.4 LAND DEGREDATION ANANYSIS

### 6.4.1 Erosion

The seven land systems present within the Study Area as mapped by Payne *et al* (1982) in the Regional Inventory of the Ashburton Rangelands and by Van Vreeswyk *et al*. (2004) in the Regional Inventory of the Pilbara Rangelands are categorised as being quite resistant to the processes of erosion (Van Vreeswyk *et al.* 2004). Van Vreeswyk *et al*. (2004) and Payne *et al* (1982) assessed the percentage of each land system that has been affected by erosion (Table 6.8). Each of the seven land systems have been subject to little or no erosion, the worst affected being the Wannamunna Land System with both minor (3%) and moderate (2%) erosion present in low levels. This data is further supported by observations made in the field where no serious erosion was observed in the Study Area.

**Table 6.8 – Erosion as Assessed by Van Vreeswyk *et al*. (2004) and Payne *et al* (1982)**

| Land System | Description | No Erosion | Minor Erosion | Moderate Erosion |
|---|---|---|---|---|
| Boolgeeda | Stony lower slopes and plains below hill systems supporting hard and soft spinifex grasslands and mulga shrublands. | 100% | 0% | 0% |
| Egerton | Dissected hardpan plains supporting mulga shrublands and hard spinifex hummock grasslands. | 100% | 0% | 0% |
| Elimunna | Stony plains on basalt supporting Sparse *Acacia* and cassia shrublands and patchy tussock grasslands. | 99% | 1% | 0% |
| Newman | Rugged jaspilite plateaux, ridges and mountains supporting hard. | 99% | 0.5% | 0.5% |
| Platform | Dissected slopes and raised plains supporting hard spinifex grasslands. | 100% | 0% | 0% |
| Rocklea | Basalt hills, plateaux, lowers slopes and minor stony plains supporting hard spinifex (and occasionally soft spinifex) grasslands. | 100% | 0% | 0% |
| Wannamunna | Hardpan plains and internal drainage tracts supporting mulga shrublands and woodlands (and occasionally eucalypt woodlands). | 95% | 3% | 2% |

### 6.4.2 Spread of Weeds

Vegetation condition ratings within the Study Area were high, with 87% of assessed quadrats being in either excellent or very good condition (Figure 5.1) with the presence of weeds within the Study Area being minimal. This is reflected by the absence of livestock as the Study Area is not located on pastoral land. Figure 4.3 demonstrates that higher densities of weeds were recorded along the rivers and creeks. Drainage lines are a major source of transportation for the most prevalent weed species in the region: *Acetosa vesicaria, Bidens bipinnata, Cenchrus ciliaris* and *Acetosa vesicaria.* These species are likely to continue to spread naturally along the river system, but alterations to flow in both volume and direction will likely facilitate the spread further.

There was also evidence to suggest that *Bidens bipinnata* is also being spread to a small degree by native fauna. *Acetosa vesicaria* was sighted growing within the 3 m buffer of the rail corridor in Deposit G. Track work and other maintenance in these areas could facilitate the spread of this species via vehicles or personnel, as well as soil disturbance. Control methods such as brush-down procedures should be used when working in these areas of the rail.

### 6.4.3 Previous Disturbance

Previous disturbance within the Study Area was observed to be predominantly from clearing pertaining to previous exploration lines, drill pads, access tracks and associated infrastructure. Deposit G is the most disturbed as part of the rail and the main access road into the West Angelas Mine are within this site. Apart from the primary disturbance from the initial clearing footprint of this infrastructure, dust is also another source of disturbance in the area. West Angeles Mine currently has management plans in place to help control the impact and spread of dust.

## 6.5 SURVEY LIMITATIONS AND CONSTRAINTS

According to the EPA Guidance Statement 51; *Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessments in Western Australia* (Environmental Protection Authority 2004), vegetation and flora surveys may be limited by several aspects. An assessment of these aspects with regard to this study is detailed in Table 6.9.

**Table 6.9– Flora and Vegetation Survey Limitations**

| Aspect | Constraint | Comment |
|---|---|---|
| Sources of information and availability of contextual information (i.e. pre-existing background versus new material) | Minor | Broad scale (1:1,000,000) mapping by Shepherd *et al* (2006) based on the mapping by Beard (1975) is available. More recently the land systems (Van Vreeswyk *et al*. 2004) have been mapped which show also broad scale regional information on vegetation communities based on land systems. Information at a local context was available with the Biota Environmental Sciences surveys in 2006 and 2010 (Biota 2006, Biota 2010), and ME Trudgen & Associates (1998), providing regional data at comparable scale of survey intensity and vegetation mapping. The lack of Species x Site matrices resulted in the need for these surveys to be compared based on their descriptions and spatial position and not on cluster analysis. |
| The scope (i.e. what life forms were sampled) | Nil | The vascular flora of the Study Area was sampled in accordance with Guidance Statement 51. |
| Proportion of flora collected and identified (based on sampling, timing and intensity) | Minor | Species accumulation curve analysis suggests that 86-88% of the taxa expected to be present were recorded. Survey timing was considered optimal, with a high proportion of plants flowering and >99% of all collections fully identified. Twenty-four of a total 6,003 specimens were not identified to species level. However, access limitations in some areas may have reduced the total inventory to a minor degree. |
| Completeness and further work which might be needed *(*e.g. was the relevant area fully surveyed) | Minor | The quadrat density of 1 quadrat per 1.17 $km^2$ is considered adequate. Quadrats were broadly distributed throughout the Study Area, however the several areas where no vehicular access was possible and distances were too great to be achieved on foot, or where the steepness of escarpments precluded access. All vegetation units were represented with at least two quadrats and in many cases more than 10.<br>Targeted surveys performed during the second were extremely beneficial to the survey with multiple locations of Priority Flora recorded. |
| Mapping reliability | Minor | For some areas, the aerial imagery as of lo resolution and was therefore blurry in its appearance, making defining vegetation community boundaries difficult at times. The number and distribution of quadrats is considered adequate for definition of vegetation within most areas, however since access to some areas was restricted, it remains possible that additional community types could be defined. |
| Timing/weather/season/cycle | Minor | The timing of the survey was optimal for most of the flora species with most recorded to be flowering or fruiting. However some of the tussock grasses collected were dry and lacked reproductive material, which resulted in challenges in completing identifications of these taxa. A survey carried out shortly following summer rains did not take place, which may have precluded the collection of some annuals and grasses. |
| Disturbances (e.g. fire, flood, accidental human intervention) | Nil | There were no natural or man-made interventions that constrained the survey. |

| Aspect | Constraint | Comment |
|---|---|---|
| Intensity (in retrospect, was the intensity adequate?) | Minor | The species accumulation curve suggests that 86-88 % of species present were collected. All vegetation units were mapped were represented by at least two quadrats. Quadrats were distributed across the Study Area at a density of 1 quadrat per 1.17 $km^2$; however the distribution was limited in some areas due to access constraints. |
| Resources | Nil | A total of 60 person-days were expended across the survey period. There was sufficient time to access all areas that could be accessed using a vehicle and foot traverses. |
| Access problems | Moderate | The majority of the survey area was easily accessed. However, the absence and poor condition of some tracks, as well as some vital tracks being recently rehabilitated required an investment of time and effort for accessing some areas on foot. The southeast and northwest areas of the larger study polygon and the centre-southeast area of the smaller study polygon were the least sampled areas due to access difficulties.<br><br>Aerial imagery and landform mapping for this area indicate that the vegetation communities in the areas where access was restricted have been sampled elsewhere. |
| Experience levels (e.g. degree of expertise in plant identification to taxon level) | Nil | The Project was overseen by the Biological Sciences Manager who has over 14 years experience in biological assessments within Western Australia, the project manager and field leader have six and two years experience, respectively. Other botanists engaged in survey work have between 1 and 5 years experience in biological surveys. The two taxonomists responsible for identifications both have Doctorates in botanical taxonomy and have completed identifications for multiple, large scale projects within the Pilbara. |

# 7 CONCLUSION

## 7.1 FLORA

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

Four specimens of the EPBC Act and the WC Act (Declared Rare Flora) listed *Lepidium catapycnon* were collected opportunistically from four locations within Greater West Angelas. A total of 29 individuals were recorded. The presence of preferred habitats beyond the location where the four specimens were collected suggest that it is possible that more individuals could be present given that access to some areas was limited during the survey. Further targeted surveys would be advantageous in defining the population.

Of the thirteen Threatened and Priority Flora taxa, five are not represented within conservation estates (*Aristida jerichoensis* var. *subspinulifera*, *Brachyscome* sp. Wanna Munna Flats (S. van Leeuwen 4662), *Brunonia* sp. long hairs (D.E. Symon 2440), *Indigofera* sp. Gilesii (M.E. Trudgen 15869) and *Triodia* sp. Mt Ella (M.E. Trudgen 12739). These taxa are considered to be of higher conservation significance, irrespective of the fact that *Aristida jerichoensis* var. *subspinulifera* (P1), *Indigofera* sp. Gilesii (M.E. Trudgen 15869) (P3) and *Triodia* sp. Mt Ella (M.E. Trudgen 12739) (P3) are relatively widespread within the Study Area.

Records from the survey include one bioregional extension, *Maireana lanosa*, although only 44 km north of the known population. Records of two taxa represent range extensions; *Corymbia zygophylla* and *Euphorbia schultzii*. These taxa represent the extent of the distribution of their species and are also of conservation significance.

## 7.2 VEGETATION

One Priority 1 PEC, West Angelas Cracking-Clays, occurs within the Study Area. In this survey it was identified as vegetation unit *AlAp* (*Aristida* and *Astrebla* grassland). The boundaries of the larger area depicted in Figure 6.1 have been ground-truthed in the field.

Vegetation units *SggIrTw* (rocky hilltops) and *AaEcTp* (sandy plains) support five individual threatened and/or priority taxa including *Lepidium catapycnon* (T). Collectively these units account for eight out of the 13 threatened and priority flora recorded. This identifies the significance of unit *SggIrTw* (where *L. catapycnon* occurs), whist also indicating that unit *AaEcTp* is of particular conservation significance.

Vegetation unit *AaPoTt* supports variable densities of *E. victrix* and therefore may be a vadophytic ecosystem (i.e. supporting plants that rely on moisture in the soil surface profile) or occasionally phreatophytic (i.e. supporting plants that rely on groundwater reservoirs), and on this basis has been qualified as a potential GDE. The vegetation unit *AaEcTp* (*Acacia* open woodland over *Eremophila* isolated shrubs over *Triodia* open grassland) supports groved and banded mulga communities and is considered likely to be sheet-flow dependent. Both of these units are sensitive to changes in hydrology.

The least extensive vegetation units locally are *AaEffTp* (141.54 ha) and *AmTw* (108.7 ha), which represent 0.80 % and 0.62% of the Study Area respectively. These units are considered to be of local significance due to their limited representation in the local context.

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# 8 STUDY TEAM

The flora and vegetation assessment in this report was planned, coordinated and executed by:

| **Project Staff and Qualifications** | | |
|---|---|---|
| Kellie Honczar | BSc | Principal Ecologist |
| Renee Young | PhD (Botany) | Senior Botanist |
| Andrew Craigie | PhD (Botany) | Taxonomist and Botanist |
| Udani Sirisena | PhD (Botany) | Taxonomist |
| Matthew Macdonald | PhD (Botany) | Senior Botanist |
| Christopher Parker | BSc | Botanist |
| Heather Broad | BSc | Botanist |

| **Licences - "Licence to Take Flora for Scientific Purposes"** | | |
|---|---|---|
| The vegetation and flora assessment described in this report was conducted under the authorisation of the following licences issued by the DEC: | | |
| | **Permit Number** | **Valid Until** |
| Matthew Macdonald | SL 009996 | 30/04/2013 |
| Andrew Craigie | SL 009990 | 30/04/2013 |
| Christopher Parker | SL 009992 | 30/04/2013 |
| Michelle Holmes | SL009998 | 30/04/2013 |
| Matthew Macdonald | SL009996 | 30/04/2013 |
| Heather Broad | SL009976 | 30/04/2013 |

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# APPENDIX A EPBC AND DEC CONSERVATION CATEGORIES

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**Table D.1 – Definition of codes for Threatened Ecological Communities**

| Code | Definition |
|---|---|
| PD: Presumed Totally Destroyed | An ecological community that has been adequately searched for but for which no representative occurrences have been located. The community has been found to be totally destroyed or so extensively modified throughout its range that no occurrence of it is likely to recover its species composition and/or structure in the foreseeable future. An ecological community will be listed as presumed totally destroyed if there are no recent records of the community being extant |
| CR: Critically Endangered | An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or that was originally of limited distribution and is facing severe modification or destruction throughout its range in the immediate future, or is already severely degraded throughout its range but capable of being substantially restored or rehabilitated. An ecological community will be listed as Critically Endangered when it has been adequately surveyed and is found to be facing an extremely high risk of total destruction in the immediate future. |
| EN: Endangered | An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or was originally of limited distribution and is in danger of significant modification throughout its range or severe modification or destruction over most of its range in the near future. An ecological community will be listed as Endangered when it has been adequately surveyed and is not Critically Endangered but is facing a very high risk of total destruction in the near future. |
| VU: Vulnerable | An ecological community that has been adequately surveyed and is found to be declining and/or has declined in distribution and/or condition and whose ultimate security has not yet been assured and/or a community that is still widespread but is believed likely to move into a category of higher threat in the near future if threatening processes continue or begin operating throughout its range. An ecological community will be listed as Vulnerable when it has been adequately surveyed and is not Critically Endangered or Endangered but is facing a high risk of total destruction or significant modification in the medium to long-term future. |

**Table D.2 – Definition of codes for Priority Ecological Communities (DEC)**

| Code | Definition |
|---|---|
| P1: Priority One | Ecological communities with apparently few, small occurrences, all or most not actively managed for conservation (e.g. within agricultural or Pastoral lands, urban areas, active mineral leases) and for which current threats exist. Communities may be included if they are comparatively well-known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range. |
| P2: Priority Two | Communities that are known from few small occurrences, all or most of which are actively managed for conservation (e.g. within national parks, conservation parks, nature reserves, State forest, unallocated Crown land, water reserves, etc.) and not under imminent threat of destruction or degradation. Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under threat from known threatening processes. |
| P3: Priority Three | (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:<br>(ii) Communities known from a few widespread occurrences, which are either large or within significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or;<br>(iii) Communities made up of large, and/or widespread occurrences that may or not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, and inappropriate fire regimes.<br>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. |
| P4: Priority Four | Ecological communities that are adequately known, Rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list. These communities require regular monitoring.<br>(a) Rare. Ecological communities known from few occurrences that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These communities are usually represented on conservation lands.<br>(b) Near Threatened. Ecological communities that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable.<br>(c) Ecological communities that have been removed from the list of threatened communities during the past five years.<br>P5: Priority Five 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. |
| P5: Priority Five | 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. |

**Table D.3 – Definition of Threatened Flora Species Categories under the *EPBC Act***

| Conservation Code | Definition |
|---|---|
| Extinct | A species is extinct if there is no reasonable doubt that the last member of the species has died. |
| Extinct in the wild | A species is categorised as extinct in the wild if it is only known to survive in cultivation, in captivity or as a naturalised population well outside its past range; or if it has not been recorded in its known/expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form. |
| Critically Endangered | The species is facing an extremely high risk of extinction in the wild in the immediate future. |
| Endangered | The species is likely to become extinct unless the circumstances and factors threatening its abundance, survival or evolutionary development cease to operate; or its numbers have been reduced to such a critical level, or its habitats have been so drastically reduced, that it is in immediate danger of extinction. |
| Vulnerable | Within the next 25 years, the species is likely to become endangered unless the circumstances and factors threatening its abundance, survival or evolutionary development cease to operate. |
| Conservation Dependent | The species is the focus of a specific conservation program, the cessation of which would result in the species becoming vulnerable, endangered or critically endangered within a period of five years. |

**Table D.4 – Definition of Declared Rare and Priority Flora Categories under the *WC Act***

| Conservation Code | Definition |
|---|---|
| DRF | Declared Rare Flora-Extant Taxa. Taxa which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such. |
| P1: Priority One | Poorly Known Taxa. Taxa which are known from one or a few (generally <5) populations which are under threat, either due to small population size, or being on lands under immediate threat, e.g. road verges, urban areas, farmland, active mineral leases, etc., or the plants are under threat, e.g. from disease, grazing by feral animals, etc. May include taxa with threatened populations on protected lands. Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey. |
| P2: Priority Two | Poorly Known Taxa. Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under immediate threat (i.e. not currently endangered). Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey. |
| P3: Priority Three | Poorly Known Taxa. Taxa which are known from several populations, and the taxa are not believed to be under immediate threat (i.e. not currently endangered), either due to the number of known populations (generally >5), or known populations being large, and either widespread or protected. Such taxa are under consideration for declaration as 'rare flora' but are in need of further survey. |
| P4: Priority Four | Rare Taxa. Taxa which are considered to have been adequately surveyed and which, whilst being rare (in Australia), are not currently threatened by any identifiable factors. These taxa require monitoring every 5-10 years. |

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# APPENDIX B COORDINATES OF FLORA QUADRATS

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| Quadrat | Botanist | Date | Zone | Easting | Northing |
|---|---|---|---|---|---|
| 2 | Heather Broad | 15/07/2012 | 50 | 677155 | 7439160 |
| 3 | Christopher Parker | 11/07/2012 | 50 | 664250 | 7434166 |
| 4 | Renee Young | 23/08/2012 | 50 | 676312 | 7432796 |
| 5 | Matthew Macdonald | 22/08/2012 | 50 | 677245 | 7438185 |
| 6 | Heather Broad | 15/07/2012 | 50 | 676964 | 7439410 |
| 7 | Andrew Craigie | 15/07/2012 | 50 | 677143 | 7440336 |
| 8 | Renee Young | 15/07/2012 | 50 | 677224 | 7439706 |
| 9 | Renee Young | 15/07/2012 | 50 | 676777 | 7439888 |
| 10 | Andrew Craigie | 15/07/2012 | 50 | 677202 | 7440980 |
| 11 | Renee Young | 11/07/2012 | 50 | 664936 | 7432362 |
| 12 | Heather Broad | 12/07/2012 | 50 | 669588 | 7436085 |
| 14 | Heather Broad | 11/07/2012 | 50 | 666335 | 7435014 |
| 15 | Christopher Parker | 11/07/2012 | 50 | 666386 | 7434420 |
| 16 | Matthew Macdonald | 23/08/2012 | 50 | 665255 | 7435767 |
| 17 | Renee Young | 11/07/2012 | 50 | 666127 | 7435443 |
| 18 | Christopher Parker | 13/07/2012 | 50 | 670256 | 7440041 |
| 19 | Andrew Craigie | 13/07/2012 | 50 | 670827 | 7440121 |
| 20 | Heather Broad | 11/07/2012 | 50 | 666544 | 7432889 |
| 21 | Andrew Craigie | 12/07/2012 | 50 | 668832 | 7436351 |
| 22 | Renee Young | 23/08/2012 | 50 | 675401 | 7433583 |
| 23 | Heather Broad | 23/08/2012 | 50 | 676745 | 7433348 |
| 24 | Andrew Craigie | 12/07/2012 | 50 | 665179 | 7437844 |
| 25 | Heather Broad | 11/07/2012 | 50 | 666551 | 7432511 |
| 26 | Heather Broad | 22/08/2012 | 50 | 665892 | 7437188 |
| 27 | Andrew Craigie | 12/07/2012 | 50 | 665237 | 7437562 |
| 28 | Heather Broad | 12/07/2012 | 50 | 663809 | 7437790 |
| 29 | Christopher Parker | 12/07/2012 | 50 | 663304 | 7437192 |
| 30 | Andrew Craigie | 23/08/2012 | 50 | 668967 | 7433839 |
| 31 | Andrew Craigie | 23/08/2012 | 50 | 666346 | 7432772 |
| 33 | Matthew Macdonald | 23/08/2012 | 50 | 668560 | 7433940 |
| 34 | Heather Broad | 23/08/2012 | 50 | 676579 | 7433252 |
| 35 | Christopher Parker | 13/07/2012 | 50 | 673632 | 7438909 |
| 36 | Renee Young | 13/07/2012 | 50 | 670777 | 7438782 |
| 37 | Heather Broad | 14/07/2012 | 50 | 687029 | 7442744 |
| 38 | Heather Broad | 14/07/2012 | 50 | 687256 | 7442411 |
| 40 | Renee Young | 14/07/2012 | 50 | 687384 | 7441660 |
| 41 | Heather Broad | 16/07/2012 | 50 | 687019 | 7440818 |
| 42 | Matthew Macdonald | 22/08/2012 | 50 | 676916 | 7438381 |
| 43 | Andrew Craigie | 13/07/2012 | 50 | 669629 | 7439904 |
| 44 | Andrew Craigie | 13/07/2012 | 50 | 672747 | 7439755 |
| 45 | Heather Broad | 10/07/2012 | 50 | 687314 | 7433554 |
| 46 | Heather Broad | 10/07/2012 | 50 | 687705 | 7433591 |
| 47 | Andrew Craigie | 22/08/2012 | 50 | 676625 | 7435967 |
| 48 | Heather Broad | 23/08/2012 | 50 | 673159 | 7435134 |
| 49 | Renee Young | 22/08/2012 | 50 | 670111 | 7435914 |
| 50 | Christopher Parker | 13/07/2012 | 50 | 673669 | 7437233 |
| 51 | Christopher Parker | 10/07/2012 | 50 | 687533 | 7432652 |
| 52 | Andrew Craigie | 10/07/2012 | 50 | 688661 | 7432669 |
| 53 | Andrew Craigie and Heather Broad | 12/07/2012 | 50 | 667899 | 7436212 |
| 54 | Christopher Parker | 12/07/2012 | 50 | 667459 | 7436044 |
| 55 | Christopher Parker | 15/07/2012 | 50 | 693252 | 7440857 |
| 56 | Christopher Parker | 15/07/2012 | 50 | 678032 | 7441255 |
| 57 | Renee Young | 22/08/2012 | 50 | 669044 | 7438284 |
| 58 | Heather Broad | 22/08/2012 | 50 | 666744 | 7437057 |
| 59 | Andrew Craigie | 22/08/2012 | 50 | 677184 | 7437539 |

| Quadrat | Botanist | Date | Zone | Easting | Northing |
|---|---|---|---|---|---|
| 60 | Matthew Macdonald | 22/08/2012 | 50 | 676676 | 7437576 |
| 61 | Renee Young | 13/07/2012 | 50 | 673215 | 7437869 |
| 62 | Andrew Craigie | 21/08/2012 | 50 | 675036 | 7437340 |
| 63 | Heather Broad | 21/08/2012 | 50 | 674380 | 7436772 |
| 64 | Renee Young | 22/08/2012 | 50 | 668923 | 7437248 |
| 65 | Renee Young | 13/07/2012 | 50 | 667686 | 7439468 |
| 66 | Heather Broad | 22/08/2012 | 50 | 671181 | 7437165 |
| 67 | Andrew Craigie | 15/07/2012 | 50 | 675707 | 7438599 |
| 68 | Christopher Parker | 15/07/2012 | 50 | 675904 | 7438645 |
| 69 | Heather Broad | 13/07/2012 | 50 | 671233 | 7439484 |
| 70 | Christopher Parker | 12/07/2012 | 50 | 662974 | 7436737 |
| 71 | Renee Young | 12/07/2012 | 50 | 663032 | 7439901 |
| 72 | Renee Young | 12/07/2012 | 50 | 662967 | 7439466 |
| 74 | Heather Broad | 12/07/2012 | 50 | 662935 | 7437760 |
| 75 | Andrew Craigie | 23/08/2012 | 50 | 664518 | 7436326 |
| 76 | Heather Broad | 15/07/2012 | 50 | 674804 | 7438827 |
| 77 | Heather Broad | 13/07/2012 | 50 | 672224 | 7439689 |
| 78 | Heather Broad | 13/07/2012 | 50 | 672023 | 7439634 |
| 79 | Andrew Craigie | 15/07/2012 | 50 | 675187 | 7438908 |
| 80 | Matthew Macdonald | 23/08/2012 | 50 | 664777 | 7435780 |
| 81 | Andrew Craigie | 23/08/2012 | 50 | 664292 | 7435990 |
| 82 | Renee Young | 15/07/2012 | 50 | 673920 | 7438834 |
| 84 | Heather Broad | 13/07/2012 | 50 | 667450 | 7440007 |
| 85 | Matthew Macdonald | 22/08/2012 | 50 | 674706 | 7436370 |
| 86 | Christopher Parker | 13/07/2012 | 50 | 670711 | 7439869 |
| 87 | Christopher Parker | 13/07/2012 | 50 | 673420 | 7439350 |
| 89 | Renee Young | 13/07/2012 | 50 | 672580 | 7439183 |
| 90 | Renee Young | 13/07/2012 | 50 | 672525 | 7439032 |
| 91 | Andrew Craigie | 22/08/2012 | 50 | 677313 | 7437373 |
| 92 | Christopher Parker | 11/07/2012 | 50 | 671795 | 7434819 |
| 93 | Andrew Craigie | 11/07/2012 | 50 | 665188 | 7433774 |
| 94 | Christopher Parker | 15/07/2012 | 50 | 675043 | 7439279 |
| 95 | Matthew Macdonald | 22/08/2012 | 50 | 676930 | 7437844 |
| 96 | Heather Broad | 15/07/2012 | 50 | 674566 | 7439117 |
| 97 | Andrew Craigie | 13/07/2012 | 50 | 672930 | 7439386 |
| 98 | Andrew Craigie | 10/07/2012 | 50 | 690021 | 7434193 |
| 99 | Renee Young | 10/07/2012 | 50 | 692404 | 7434579 |
| 100 | Andrew Craigie | 11/07/2012 | 50 | 665048 | 7433112 |
| 102 | Andrew Craigie | 11/07/2012 | 50 | 673591 | 7434348 |
| 103 | Renee Young | 11/07/2012 | 50 | 665617 | 7432674 |
| 104 | Andrew Craigie | 22/08/2012 | 50 | 676037 | 7437964 |
| 105 | Christopher Parker | 10/07/2012 | 50 | 689329 | 7433993 |
| 106 | Andrew Craigie | 10/07/2012 | 50 | 690813 | 7434491 |
| 107 | Renee Young | 10/07/2012 | 50 | 691959 | 7434259 |
| 108 | Andrew Craigie | 10/07/2012 | 50 | 687622 | 7432995 |
| 109 | Renee Young | 10/07/2012 | 50 | 692133 | 7434084 |
| 110 | Renee Young | 10/07/2012 | 50 | 688061 | 7433951 |
| 111 | Andrew Craigie | 10/07/2012 | 50 | 690781 | 7434606 |
| 112 | Christopher Parker | 10/07/2012 | 50 | 689514 | 7433871 |
| 113 | Renee Young | 10/07/2012 | 50 | 687687 | 7434485 |
| 114 | Heather Broad | 10/07/2012 | 50 | 691391 | 7433665 |
| 115 | Heather Broad | 10/07/2012 | 50 | 691478 | 7433848 |
| 116 | Matthew Macdonald | 25/08/2012 | 50 | 689743 | 7432298 |
| 117 | Matthew Macdonald | 25/08/2012 | 50 | 692296 | 7432269 |
| 118 | Matthew Macdonald | 25/08/2012 | 50 | 691903 | 7432228 |
| 119 | Christopher Parker | 10/07/2012 | 50 | 687390 | 7432574 |
| 120 | Renee Young | 25/08/2012 | 50 | 688668 | 7435466 |
| 121 | Heather Broad | 25/08/2012 | 50 | 690898 | 7435543 |

| Quadrat | Botanist | Date | Zone | Easting | Northing |
|---|---|---|---|---|---|
| 122 | Heather Broad | 25/08/2012 | 50 | 690568 | 7435562 |
| 123 | Andrew Craigie | 18/07/2012 | 50 | 691442 | 7435304 |
| 124 | Andrew Craigie | 18/07/2012 | 50 | 690998 | 7435051 |
| 125 | Renee Young | 25/08/2012 | 50 | 689448 | 7435600 |
| 126 | Heather Broad | 18/07/2012 | 50 | 692362 | 7435225 |
| 127 | Heather Broad | 18/07/2012 | 50 | 691897 | 7435262 |
| 128 | Renee Young | 14/07/2012 | 50 | 687617 | 7441806 |
| 129 | Andrew Craigie | 16/07/2012 | 50 | 687534 | 7441102 |
| 130 | Andrew Craigie | 12/07/2012 | 50 | 689733 | 7439848 |
| 131 | Christopher Parker | 17/07/2012 | 50 | 690405 | 7440055 |
| 132 | Heather Broad | 17/07/2012 | 50 | 690710 | 7440192 |
| 133 | Heather Broad | 17/07/2012 | 50 | 690774 | 7440465 |
| 134 | Andrew Craigie | 17/07/2012 | 50 | 689997 | 7440750 |
| 135 | Christopher Parker | 14/07/2012 | 50 | 694775 | 7442645 |
| 136 | Andrew Craigie | 14/07/2012 | 50 | 695085 | 7442608 |
| 137 | Christopher Parker | 14/07/2012 | 50 | 693742 | 7442990 |
| 138 | Andrew Craigie | 14/07/2012 | 50 | 694996 | 7443069 |
| 139 | Christopher Parker | 17/07/2012 | 50 | 691396 | 7441959 |
| 140 | Heather Broad | 16/07/2012 | 50 | 692860 | 7442223 |
| 141 | Christopher Parker | 16/07/2012 | 50 | 677807 | 7440841 |
| 142 | Andrew Craigie | 17/07/2012 | 50 | 691561 | 7441218 |
| 143 | Heather Broad | 24/08/2012 | 50 | 692043 | 7440355 |
| 144 | Heather Broad | 24/08/2012 | 50 | 691601 | 7440107 |
| 145 | Christopher Parker | 17/07/2012 | 50 | 690919 | 7440001 |
| 146 | Andrew Craigie; Christopher Parker and Heather Broad | 17/07/2012 | 50 | 689963 | 7441587 |
| 147 | Heather Broad | 17/07/2012 | 50 | 690015 | 7442078 |
| 148 | Andrew Craigie | 15/07/2012 | 50 | 694100 | 7441820 |
| 149 | Andrew Craigie | 16/07/2012 | 50 | 694618 | 7441708 |
| 151 | Christopher Parker | 14/07/2012 | 50 | 693738 | 7443431 |
| 152 | Andrew Craigie | 14/07/2012 | 50 | 695697 | 7443107 |
| 153 | Heather Broad | 16/07/2012 | 50 | 692827 | 7441627 |
| 154 | Christopher Parker | 16/07/2012 | 50 | 693821 | 7440864 |
| 155 | Matthew Macdonald | 24/08/2012 | 50 | 689478 | 7442994 |
| 156 | Matthew Macdonald | 24/08/2012 | 50 | 688740 | 7443153 |
| 160 | Christopher Parker | 16/07/2012 | 50 | 687010 | 7441224 |
| 200 | Renee Young | 23/08/2012 | 50 | 673438 | 7437317 |
| 201 | Renee Young and Heather Broad | 23/08/2012 | 50 | 677257 | 7442559 |

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# APPENDIX C FLORA SPECIES RECORDED AT WEST ANGELAS

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| Family | Taxon | Observation |
|---|---|---|
| Acanthaceae | *Dicladanthera forrestii* | |
| | *Dipteracanthus australasicus* subsp. *australasicus* | |
| | *Harnieria kempeana* subsp. *muelleri* | |
| Aizoaceae | *Trianthema glossostigma* | |
| Amaranthaceae | *Achyranthes aspera* | |
| | *Alternanthera nana* | |
| | *Amaranthus cuspidifolius* | |
| | *Amaranthus mitchellii* | |
| | *Gomphrena affinis* subsp. *pilbarensis* | |
| | *Gomphrena canescens* | |
| | *Gomphrena cunninghamii* | |
| | *Gomphrena kanisii* | |
| | *Ptilotus aervoides* | |
| | *Ptilotus astrolasius* | |
| | *Ptilotus auriculifolius* | |
| | *Ptilotus calostachyus* | |
| | *Ptilotus carinatus* | |
| | *Ptilotus clementii* | |
| | *Ptilotus fusiformis* | |
| | *Ptilotus gomphrenoides* | |
| | *Ptilotus helipteroides* | |
| | *Ptilotus nobilis* subsp. *nobilis* | |
| | *Ptilotus obovatus* | |
| | *Ptilotus polystachyus* | |
| | *Ptilotus roei* | |
| | *Ptilotus rotundifolius* | |
| | *Ptilotus schwartzii* var. *schwartzii* | |
| Apocynaceae | *Cynanchum floribundum* | |
| | *Marsdenia australis* | |
| | *Rhyncharrhena linearis* | |
| | *Sarcostemma viminale* subsp. *australe* | |
| Araliaceae | *Astrotricha hamptonii* | |
| | *Trachymene oleracea* subsp. *oleracea* | |
| | *Trachymene pilbarensis* | |
| Asteraceae | *Bidens bipinnata* | Invasive |
| | *Brachyscome* sp. Wanna Munna Flats (S. van Leeuwen 4662) | P1 |
| | *Calocephalus knappii* | |
| | *Calotis multicaulis* | |
| | *Calotis porphyroglossa* | |
| | *Chrysocephalum apiculatum* | |
| | *Chrysocephalum eremaeum* | |
| | *Chrysocephalum gilesii* | |
| | *Chrysocephalum pterochaetum* | |
| | *Flaveria trinervia* | Invasive |
| | *Peripleura arida* | |
| | *Peripleura hispidula* var. *setosa* | |
| | *Peripleura obovata* | |
| | *Pluchea dentex* | |
| | *Pluchea dunlopii* | |
| | *Pterocaulon serrulatum* | |
| | *Pterocaulon sphacelatum* | |
| | *Rhodanthe citrina* | |
| | *Rhodanthe floribunda* | |
| | *Rhodanthe margarethae* | |
| | *Sigesbeckia orientalis* | Invasive |

| Family | Taxon | Observation |
|---|---|---|
| Asteraceae | *Streptoglossa bubakii* | |
| | *Streptoglossa decurrens* | |
| | *Streptoglossa liatroides* | |
| | *Streptoglossa odora* | |
| | *Streptoglossa tenuiflora* | |
| | *Vittadinia eremaea* | |
| Boraginaceae | *Halgania gustafsenii* | |
| | *Heliotropium chrysocarpum* | |
| | *Heliotropium cunninghamii* | |
| | *Heliotropium heteranthum* | |
| | *Heliotropium inexplicitum* | |
| | *Heliotropium pachyphyllum* | |
| | *Heliotropium tenuifolium* | |
| | *Trichodesma zeylanicum* | |
| | *Trichodesma zeylanicum* var. *zeylanicum* | |
| Brassicaceae | *Lepidium catapycnon* | T |
| | *Lepidium pedicellosum* | |
| | *Lepidium phlebopetalum* | |
| | *Lepidium pholidogynum* | |
| | *Lepidium platypetalum* | |
| Campanulaceae | *Isotoma petraea* | |
| | *Lobelia heterophylla* | |
| | *Wahlenbergia tumidifructa* | |
| Capparaceae | *Capparis lasiantha* | |
| | *Capparis mitchellii* | |
| | *Capparis spinosa* var. *nummularia* | |
| Caryophyllaceae | *Polycarpaea corymbosa* | |
| | *Polycarpaea holtzei* | |
| | *Polycarpaea longiflora* | |
| Celastraceae | *Denhamia cunninghamii* | |
| | *Maytenus* sp. Mt Windell (S. van Leeuwen 846) | |
| | *Stackhousia intermedia* | |
| Chenopodiaceae | *Dissocarpus paradoxus* | |
| | *Dysphania glomulifera* | |
| | *Dysphania glomulifera* subsp. *eremaea* | |
| | *Dysphania kalpari* | |
| | *Dysphania rhadinostachya* subsp. *rhadinostachya* | |
| | *Enchylaena tomentosa* var. *tomentosa* | |
| | *Maireana georgei* | |
| | *Maireana lanosa* | |
| | *Maireana melanocoma* | |
| | *Maireana planifolia* | |
| | *Maireana tomentosa* | |
| | *Maireana triptera* | |
| | *Maireana villosa* | |
| | *Rhagodia eremaea* | |
| | *Rhagodia* sp. Hamersley (M. Trudgen 17794) PN | P3 |
| | *Salsola australis* | |
| | *Sclerolaena convexula* | |
| | *Sclerolaena cornishiana* | |
| | *Sclerolaena eriacantha* | |
| | *Sclerolaena tetragona* | |
| Cleomaceae | *Cleome viscosa* | |
| Convolvulaceae | *Convolvulus clementii* | |
| | *Duperreya commixta* | |
| | *Evolvulus alsinoides* | |
| | *Evolvulus alsinoides* var. *decumbens* | |
| | *Evolvulus alsinoides* var. *villosicalyx* | |

| Family | Taxon | Observation |
|---|---|---|
| | *Ipomoea muelleri* | |
| | *Ipomoea polymorpha* | |
| | *Operculina aequisepala* | |
| | *Polymeria ambigua* | |
| Cucurbitaceae | *Cucumis variabilis* | |
| Cyperaceae | *Bulbostylis barbata* | |
| | *Cyperus cunninghamii* subsp. *cunninghamii* | |
| | *Fimbristylis dichotoma* | |
| | *Fimbristylis simulans* | |
| Euphorbiaceae | *Adriana tomentosa* var. *tomentosa* | |
| | *Euphorbia alsiniflora* | |
| | *Euphorbia australis* | |
| | *Euphorbia biconvexa* | |
| | *Euphorbia boophthona* | |
| | *Euphorbia drummondii* | |
| | *Euphorbia schultzii* | |
| Fabaceae | *Acacia adoxa* var. *adoxa* | |
| | *Acacia adsurgens* | |
| | *Acacia ancistrocarpa* | |
| | *Acacia aptaneura* | |
| | *Acacia atkinsiana* | |
| | *Acacia ayersiana* | |
| | *Acacia bivenosa* | |
| | *Acacia catenulata* subsp. *occidentalis* | |
| | *Acacia citrinoviridis* | |
| | *Acacia colei* var. *colei* | |
| | *Acacia cowleana* | |
| | *Acacia dictyophleba* | |
| | *Acacia eriopoda* | |
| | *Acacia hamersleyensis* | |
| | *Acacia inaequilatera* | |
| | *Acacia incurvaneura* | |
| | *Acacia macraneura* | |
| | *Acacia maitlandii* | |
| | *Acacia marramamba* | |
| | *Acacia minyura* | |
| | *Acacia monticola* | |
| | *Acacia pachyacra* | |
| | *Acacia pruinocarpa* | |
| | *Acacia pteraneura* | |
| | *Acacia pyrifolia* | |
| | *Acacia pyrifolia* var. *pyrifolia* | |
| | *Acacia rhodophloia* | |
| | *Acacia sibirica* | |
| | *Acacia* aff. *subtiliformis* | P3 |
| | *Acacia synchronicia* | |
| | *Acacia tenuissima* | |
| | *Acacia tetragonophylla* | |
| | *Acacia validinervia* | |
| | *Crotalaria medicaginea* var. *neglecta* | |
| | *Crotalaria novae-hollandiae* subsp. *novae-hollandiae* | |
| | *Cullen leucochaites* | |
| | *Gastrolobium grandiflorum* | |
| | *Glycine canescens* | |
| | *Gompholobium oreophilum* | |
| | *Indigofera fractiflexa* | |
| | *Indigofera georgei* | |
| | *Indigofera* sp. Gilesii (M.E. Trudgen 15869) | P3 |

| Family | Taxon | Observation |
|---|---|---|
| Fabaceae | *Indigofera monophylla* | |
| | *Indigofera rugosa* | |
| | *Isotropis forrestii* | |
| | *Mirbelia viminalis* | |
| | *Petalostylis labicheoides* | |
| | *Rhynchosia minima* | |
| | *Senna artemisioides* subsp. *filifolia* | |
| | *Senna artemisioides* subsp. *helMSii* | |
| | *Senna artemisioides* subsp. *oligophylla* | |
| | *Senna artemisioides* subsp. *x artemisioides* | |
| | *Senna ferraria* | |
| | *Senna glutinosa* subsp. *glutinosa* | |
| | *Senna glutinosa* subsp. *pruinosa* | |
| | *Senna glutinosa* subsp. *x luerssenii* | |
| | *Senna hamersleyensis* | |
| | *Senna notabilis* | |
| | *Senna pleurocarpa* var. *angustifolia* | |
| | *Senna sericea* | |
| | *Senna* sp. Meekatharra (E. Bailey 1-26) | |
| | *Senna stricta* | |
| | *Senna symonii* | |
| | *Swainsona kingii* | |
| | *Swainsona maccullochiana* | |
| | *Templetonia egena* | |
| | *Tephrosia clementii* | |
| | *Tephrosia densa* | |
| | *Tephrosia rosea* var. *glabrior* | |
| | *Tephrosia supina* | |
| | *Vachellia farnesiana* | Invasive |
| | *Vigna* sp. Hamersley Clay (A.A. Mitchell PRP 113) | |
| Goodeniaceae | *Brunonia* sp. long hairs (D.E. Symon 2440) PN | P1 |
| | *Dampiera candicans* | |
| | *Goodenia microptera* | |
| | *Goodenia muelleriana* | |
| | *Goodenia nuda* | P4 |
| | *Goodenia scaevolina* | |
| | *Goodenia stellata* | |
| | *Goodenia stobbsiana* | |
| | *Goodenia tenuiloba* | |
| | *Goodenia triodiophila* | |
| | *Scaevola browniana* subsp. *browniana* | |
| | *Scaevola parvifolia* | |
| | *Scaevola parvifolia* subsp. *pilbarae* | |
| | *Scaevola spinescens* | |
| Gyrostemonaceae | *Codonocarpus cotinifolius* | |
| Haloragaceae | *Haloragis gossei* | |
| | *Haloragis gossei* var. *gossei* | |
| | *Haloragis gossei* var. *inflata* | |
| Hemerocallidaceae | *Corynotheca micrantha* | |
| Lamiaceae | *Clerodendrum floribundum* | |
| | *Clerodendrum floribundum* var. *angustifolium* | |
| | *Newcastelia* sp. *Hamersley Range (S. van Leeuwen 4264)* | |
| | *Spartothamnella teucriiflora* | |
| Lauraceae | *Cassytha capillaris* | |
| Loranthaceae | *Amyema hilliana* | |
| | *Amyema miquelii* | |
| Malvaceae | *Abutilon amplum* | |
| | *Abutilon cryptopetalum* | |

| Family | Taxon | Observation |
|---|---|---|
| Malvaceae | *Abutilon cunninghamii* | |
| | *Abutilon dioicum* | |
| | *Abutilon fraseri* subsp. *fraseri* | |
| | *Abutilon lepidum* | |
| | *Abutilon leucopetalum* | |
| | *Abutilon macrum* | |
| | *Abutilon otocarpum* | |
| | *Abutilon oxycarpum* | |
| | *Abutilon trudgenii* MS | |
| | *Androcalva luteiflora* | |
| | *Corchorus crozophorifolius* | |
| | *Corchorus lasiocarpus* | |
| | *Corchorus lasiocarpus* subsp. *parvus* | |
| | *Corchorus sidoides* subsp. *sidoides* | |
| | *Corchorus tridens* | |
| | *Gossypium australe* | |
| | *Gossypium robinsonii* | |
| | *Hibiscus burtonii* | |
| | *Hibiscus coatesii* | |
| | *Hibiscus gardneri* | |
| | *Hibiscus sturtii* | |
| | *Hibiscus sturtii* var. *campylochlamys* | |
| | *Hibiscus sturtii* var. *platychlamys* | |
| | *Hibiscus trionum* | |
| | *Keraudrenia velutina* | |
| | *Malvastrum americanum* | Invasive |
| | *Melhania oblongifolia* | |
| | *Sida arenicola* | |
| | *Sida arsiniata* | |
| | *Sida echinocarpa* | |
| | *Sida ectogama* | |
| | *Sida fibulifera* | |
| | *Sida* sp. Barlee Range (S. van Leeuwen 1642) PN | P3 |
| | *Sida* sp. dark green fruit (S. van Leeuwen 2260) | |
| | *Sida* sp. Golden calyces glabrous (H.N. Foote 32) | |
| | *Sida* sp. Pilbara (A.A. Mitchell PRP 1543) | |
| | *Sida* sp. Shovelanna Hill (S. van Leeuwen 3842) | |
| | *Sida* sp. spiciform panicles (E. Leyland s.n. 14/8/1990 | |
| | *Sida* sp. Supplejack Station (T.S. Henshall 2345) | |
| | *Sida* sp. verrucose glands (F.H. Mollemans 2423) | |
| | *Sida spinosa* | |
| | *Sida trichopoda* | |
| | *Triumfetta leptacantha* | |
| | *Waltheria indica* | |
| Marsileaceae | *Marsilea hirsuta* | |
| Moraceae | *Ficus brachypoda* | |
| Myrtaceae | *Calytrix carinata* | |
| | *Corymbia candida* | |
| | *Corymbia deserticola* subsp. *deserticola* | |
| | *Corymbia hamersleyana* | |
| | *Corymbia zygophylla* | |
| | *Eucalyptus gamophylla* | |
| | *Eucalyptus leucophloia* | |
| | *Eucalyptus leucophloia* subsp. *leucophloia* | |
| | *Eucalyptus pilbarensis* | |
| | *Eucalyptus socialis* subsp. *eucentrica* | |
| | *Eucalyptus trivalva* | |
| | *Eucalyptus victrix* | |

| Family | Taxon | Observation |
|---|---|---|
| Myrtaceae | *Eucalyptus xerothermica* | |
| | *Melaleuca eleuterostachya* | |
| Nyctaginaceae | *Boerhavia coccinea* | |
| | *Boerhavia paludosa* | |
| Oleaceae | *Jasminum didymum* subsp. *lineare* | |
| Phyllanthaceae | *Notoleptopus decaisnei* | |
| | *Phyllanthus erwinii* | |
| | *Phyllanthus maderaspatensis* | |
| Pittosporaceae | *Pittosporum angustifolium* | |
| Poaceae | *Acrachne racemosa* | |
| | *Amphipogon sericeus* | |
| | *Aristida burbidgeae* | |
| | *Aristida contorta* | |
| | *Aristida holathera* var. *holathera* | |
| | *Aristida ingrata* | |
| | *Aristida jerichoensis* var. *subspinulifera* | P1 |
| | *Aristida latifolia* | |
| | *Aristida lazaridis* | P2 |
| | *Aristida obscura* | |
| | *Astrebla pectinata* | |
| | *Bothriochloa ewartiana* | |
| | *Brachyachne ciliaris* | |
| | *Brachyachne convergens* | |
| | *Cenchrus ciliaris* | Invasive |
| | *Chloris pectinata* | |
| | *Chrysopogon fallax* | |
| | *Cymbopogon ambiguus* | |
| | *Cymbopogon obtectus* | |
| | *Cymbopogon procerus* | |
| | *Dichanthium sericeum* | |
| | *Digitaria brownii* | |
| | *Digitaria ctenantha* | |
| | *Enneapogon avenaceus* | |
| | *Enneapogon caerulescens* | |
| | *Enneapogon intermedius* | |
| | *Enneapogon lindleyanus* | |
| | *Enneapogon pallidus* | |
| | *Enneapogon polyphyllus* | |
| | *Enneapogon robustissimus* | |
| | *Eragrostis cumingii* | |
| | *Eragrostis desertorum* | |
| | *Eragrostis dielsii* | |
| | *Eragrostis eriopoda* | |
| | *Eragrostis falcata* | |
| | *Eragrostis pergracilis* | |
| | *Eragrostis setifolia* | |
| | *Eragrostis tenellula* | |
| | *Eragrostis xerophila* | |
| | *Eriachne helmsii* | |
| | *Eriachne lanata* | |
| | *Eriachne mucronata* | |
| | *Eriachne pulchella* subsp. *dominii* | |
| | *Eriachne pulchella* subsp. *pulchella* | |
| | *Eulalia aurea* | |
| | *Ischaemum albovillosum* | |
| | *Iseilema eremaeum* | |
| | *Iseilema membranaceum* | |
| | *Iseilema vaginiflorum* | |

| Family | Taxon | Observation |
|---|---|---|
| Poaceae | *Panicum decompositum* | |
| | *Panicum effusum* | |
| | *Panicum laevinode* | |
| | *Paraneurachne muelleri* | |
| | *Paspalidium basicladum* | |
| | *Paspalidium clementii* | |
| | *Paspalidium constrictum* | |
| | *Paspalidium rarum* | |
| | *Perotis rara* | |
| | *Setaria dielsii* | |
| | *Setaria surgens* | |
| | *Sporobolus australasicus* | |
| | *Themeda* sp. Hamersley Station (M.E. Trudgen 11431) PN | P3 |
| | *Themeda triandra* | |
| | *Tragus australianus* | |
| | *Triodia basedowii* | |
| | *Triodia brizoides* | |
| | *Triodia longiceps* | |
| | *Triodia melvillei* | |
| | *Triodia pungens* | |
| | *Triodia* sp. Mt Ella (M.E. Trudgen 12739) | P3 |
| | *Triodia wiseana* | |
| | *Tripogon loliiformis* | |
| | *Triraphis mollis* | |
| | *Urochloa occidentalis* var. *occidentalis* | |
| | *Yakirra australiensis* | |
| | *Yakirra australiensis* var. *australiensis* | |
| Polygalaceae | *Polygala isingii* | |
| Portulacaceae | *Calandrinia* sp. The Pink Hills (F. Obbens FO 19/06) | |
| | *Portulaca oleracea* | Invasive |
| Proteaceae | *Grevillea berryana* | |
| | *Grevillea stenobotrya* | |
| | *Grevillea wickhamii* | |
| | *Grevillea wickhamii* subsp. *hispidula* | |
| | *Hakea chordophylla* | |
| | *Hakea lorea* subsp. *lorea* | |
| Pteridaceae | *Cheilanthes lasiophylla* | |
| | *Cheilanthes sieberi* subsp. *sieberi* | |
| Rhamnaceae | *Cryptandra monticola* | |
| | *Ventilago viminalis* | |
| Rubiaceae | *Oldenlandia crouchiana* | |
| | *Psydrax latifolia* | |
| | *Psydrax suaveolens* | |
| | *Spermacoce brachystema* | |
| Santalaceae | *Exocarpos sparteus* | |
| | *Santalum lanceolatum* | |
| | *Santalum spicatum* | |
| Sapindaceae | *Dodonaea coriacea* | |
| | *Dodonaea lanceolata* var. *lanceolata* | |
| | *Dodonaea pachyneura* | |
| | *Dodonaea viscosa* subsp. *mucronata* | |
| | *Dodonaea viscosa* subsp. *spatulata* | |
| Scrophulariaceae | *Eremophila caespitosa* | |
| | *Eremophila clarkei* | |
| | *Eremophila cuneifolia* | |
| | *Eremophila exilifolia* | |
| | *Eremophila forrestii* subsp. *forrestii* | |
| | *Eremophila forrestii* subsp. Pingandy (M.E. Trudgen 2662) | P2 |

| Family | Taxon | Observation |
|---|---|---|
| Scrophulariaceae | *Eremophila fraseri* subsp. *fraseri* | |
| | *Eremophila galeata* | |
| | *Eremophila jucunda* subsp. *pulcherrima* | |
| | *Eremophila lanceolata* | |
| | *Eremophila latrobei* | |
| | *Eremophila latrobei* subsp. *filiformis* | |
| | *Eremophila latrobei* subsp. *latrobei* | |
| | *Eremophila longifolia* | |
| | *Eremophila phyllopoda* subsp. *obliqua* | |
| | *Eremophila platycalyx* subsp. *pardalota* | |
| | *Eremophila tietkensii* | |
| Solanaceae | *Nicotiana benthamiana* | |
| | *Nicotiana occidentalis* | |
| | *Nicotiana simulans* | |
| | *Solanum centrale* | |
| | *Solanum horridum* | |
| | *Solanum lasiophyllum* | |
| | *Solanum phlomoides* | |
| | *Solanum sturtianum* | |
| Surianaceae | *Stylobasium spathulatum* | |
| Violaceae | *Hybanthus aurantiacus* | |
| Zygophyllaceae | *Tribulus astrocarpus* | |
| | *Tribulus hirsutus* | |
| | *Tribulus macrocarpus* | |
| | *Tribulus occidentalis* | |
| | *Tribulus suberosus* | |
| | *Zygophyllum eichleri* | |
| | *Zygophyllum iodocarpum* | |

# APPENDIX D COORDINATES OF PRIORITY FLORA AT WEST ANGELAS

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| Species | Status | Zone | Easting | Northing | Number of plants |
|---|---|---|---|---|---|
| *Acacia* aff. *subtiliformis* | P3 | 50 | 668980 | 7438136 | 120 |
| | | 50 | 668950 | 7438192 | 10 |
| | | 50 | 668906 | 7438285 | 120 |
| *Aristida jerichoensis* var. *subspinulifera* | P1 | 50 | 677203 | 7440980 | 10 |
| | | 50 | 687314 | 7433555 | 30 |
| | | 50 | 673160 | 7435134 | 5 |
| | | 50 | 688661 | 7432670 | 10 |
| | | 50 | 662974 | 7436737 | 5 |
| | | 50 | 673920 | 7438834 | 5 |
| | | 50 | 677314 | 7437374 | 10 |
| | | 50 | 691479 | 7433849 | 10 |
| | | 50 | 689743 | 7432298 | 10 |
| | | 50 | 691904 | 7432228 | 10 |
| | | 50 | 687390 | 7432574 | 5 |
| | | 50 | 691443 | 7435305 | 10 |
| | | 50 | 693821 | 7440864 | 5 |
| | | 50 | 689229 | 7432625 | 20 |
| | | 50 | 688666 | 7443264 | 1 |
| | | 50 | 691399 | 7432870 | 10 |
| | | 50 | 687804 | 7432698 | 6 |
| | | 50 | 691532 | 7432839 | 5 |
| | | 50 | 687467 | 7432718 | 100 |
| | | 50 | 687911 | 7433195 | 50 |
| | | 50 | 687463 | 7433153 | 20 |
| | | 50 | 691430 | 7432855 | 20 |
| | | 50 | 687528 | 7433614 | 50 |
| | | 50 | 688590 | 7432715 | 50 |
| | | 50 | 688445 | 7432704 | 30 |
| | | 50 | 691194 | 7432900 | 1 |
| | | 50 | 687468 | 7433386 | 100 |
| | | 50 | 691475 | 7432849 | 5 |
| | | 50 | 690693 | 7432924 | 1 |
| | | 50 | 687835 | 7433535 | 1 |
| | | 50 | 688387 | 7432677 | 50 |
| | | 50 | 689426 | 7432862 | 6 |
| | | 50 | 688612 | 7433353 | 20 |
| | | 50 | 687809 | 7432691 | 100 |
| | | 50 | 689375 | 7432556 | 1000 |
| | | 50 | 688885 | 7432701 | 5 |
| | | 50 | 688301 | 7432615 | 1 |
| | | 50 | 689526 | 7432891 | 2 |
| | | 50 | 687463 | 7433153 | 100 |
| | | 50 | 691662 | 7432824 | 10 |
| | | 50 | 690208 | 7435391 | 50 |
| | | 50 | 689267 | 7432603 | 30 |
| | | 50 | 687468 | 7433386 | 20 |
| | | 50 | 688741 | 7432699 | 5 |
| *Aristida lazaridis* | P2 | 50 | 694996 | 7443069 | 5 |
| | | 50 | 689585 | 7432449 | 20 |
| | | 50 | 688575 | 7432716 | 2 |
| *Brachyscome* sp. Wanna Munna Flats (S. van Leeuwen 4662) PN | P1 | 50 | 688703 | 7432676 | 1 |
| | | 50 | 674380 | 7436772 | 2 |
| *Brunonia* sp. long hairs (D.E. Symon 2440) PN | P1 | 50 | 664936 | 7432362 | 2 |
| | | 50 | 663304 | 7437192 | 5 |
| | | 50 | 663032 | 7439901 | 2 |
| | | 50 | 673669 | 7437233 | 5 |
| | | 50 | 677224 | 7439706 | 2 |

| Species | Status | Zone | Easting | Northing | Number of plants |
|---|---|---|---|---|---|
| | | 50 | 673438 | 7437317 | 15 |
| | | 50 | 669408 | 7433885 | 1 |
| | | 50 | 691903 | 7432228 | 1 |
| | | 50 | 668858 | 7438440 | 1 |
| | | 50 | 668657 | 7437327 | 2 |
| *Eremophila forrestii* subsp. Pingandy (M.E. Trudgen 2662) | P2 | 50 | 676965 | 7438393 | 1 |
| *Goodenia nuda* | P4 | 50 | 673438 | 7437317 | 5 |
| | | 50 | 688964 | 7435518 | 2 |
| *Indigofera* sp. Gilesii (M.E. Trudgen 15869) | P3 | 50 | 690781 | 7434606 | 15 |
| | | 50 | 689514 | 7433871 | 2 |
| | | 50 | 689653 | 7433877 | 3 |
| | | 50 | 689632 | 7433869 | 10 |
| | | 50 | 689310 | 7433800 | 16 |
| | | 50 | 678032 | 7441255 | 15 |
| | | 50 | 689963 | 7441587 | 16 |
| | | 50 | 690998 | 7441857 | 1 |
| | | 50 | 691049 | 7441944 | 1 |
| | | 50 | 691203 | 7441994 | 10 |
| | | 50 | 691229 | 7441997 | 4 |
| | | 50 | 691240 | 7441996 | 1 |
| | | 50 | 688927 | 7443254 | 100 |
| | | 50 | 690382 | 7441946 | 12 |
| | | 50 | 690401 | 7441890 | 10 |
| | | 50 | 690408 | 7441885 | 10 |
| | | 50 | 689919 | 7441031 | 1 |
| | | 50 | 687791 | 7434256 | 2 |
| | | 50 | 688725 | 7433695 | 5 |
| | | 50 | 689007 | 7435225 | 1 |
| | | 50 | 689050 | 7434996 | 15 |
| | | 50 | 689055 | 7434985 | 14 |
| | | 50 | 689065 | 7434969 | 15 |
| *Lepidium catapycnon* | T | 50 | 688710 | 7443257 | 20 |
| | | 50 | 688715 | 7443269 | 1 |
| | | 50 | 688716 | 7443281 | 1 |
| | | 50 | 688685 | 7443292 | 7 |
| *Rhagodia* sp. Hamersley (M. Trudgen 17794) PN | P3 | 50 | 691478 | 7433848 | 2 |
| | | 50 | 671233 | 7439484 | 2 |
| | | 50 | 672580 | 7439183 | 2 |
| | | 50 | 676135 | 7435721 | 3 |
| | | 50 | 676538 | 7435987 | 1 |
| | | 50 | 677340 | 7435770 | 5 |
| | | 50 | 676625 | 7435967 | 5 |
| | | 50 | 674706 | 7436370 | 5 |
| | | 50 | 676519 | 7435975 | 5 |
| | | 50 | 688643 | 7443253 | 1 |
| | | 50 | 688669 | 7443262 | 1 |
| | | 50 | 688772 | 7443255 | 1 |
| | | 50 | 688894 | 7443243 | 4 |
| | | 50 | 688927 | 7443254 | 6 |
| | | 50 | 688948 | 7443252 | 4 |
| | | 50 | 688962 | 7443250 | 3 |
| | | 50 | 689046 | 7443256 | 4 |
| | | 50 | 691903 | 7432228 | 5 |
| | | 50 | 687430 | 7432920 | 5 |
| | | 50 | 687435 | 7432957 | 1 |
| | | 50 | 687437 | 7432975 | 1 |
| | | 50 | 687435 | 7432990 | 1 |

| Species | Status | Zone | Easting | Northing | Number of plants |
|---|---|---|---|---|---|
| | | 50 | 687474 | 7433203 | 5 |
| | | 50 | 687803 | 7434230 | 1 |
| | | 50 | 687917 | 7433186 | 2 |
| | | 50 | 688055 | 7432954 | 8 |
| | | 50 | 688511 | 7433194 | 6 |
| | | 50 | 690364 | 7432322 | 1 |
| | | 50 | 691515 | 7432320 | 4 |
| | | 50 | 691647 | 7432290 | 1 |
| | | 50 | 691872 | 7432200 | 1 |
| *Sida* sp. Barlee Range (S. van Leeuwen 1642) PN | P3 | 50 | 694100 | 7441820 | 5 |
| | | 50 | 668560 | 7433940 | 10 |
| | | 50 | 691335 | 7441998 | 3 |
| | | 50 | 691350 | 7441983 | 1 |
| | | 50 | 692537 | 7442144 | 1 |
| | | 50 | 692644 | 7442173 | 4 |
| | | 50 | 692649 | 7442186 | 30 |
| *Themeda* sp. Hamersley Station (M.E. Trudgen 11431) PN | P3 | 50 | 675904 | 7438645 | 5 |
| | | 50 | 675043 | 7439279 | 15 |
| | | 50 | 675036 | 7437340 | 15 |
| | | 50 | 677034 | 7437867 | ~500 |
| | | 50 | 672958 | 7437985 | 1000 |
| | | 50 | 674453 | 7438046 | 1000 |
| | | 50 | 674839 | 7437923 | 1000 |
| *Triodia* sp. Mt Ella (M.E. Trudgen 12739) | P3 | 50 | 690781 | 7434606 | 30 |
| | | 50 | 668560 | 7433940 | 5 |
| | | 50 | 675528 | 7433693 | 50 |
| | | 50 | 668709 | 7434062 | 100 |
| | | 50 | 676312 | 7432796 | 32 |
| | | 50 | 691966 | 7442312 | 50 |
| | | 50 | 691899 | 7442318 | 20 |
| | | 50 | 691875 | 7442317 | 50 |

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# APPENDIX E RARE AND PRIORITY FLORA REPORT FORMS

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# APPENDIX F WEED CATEGORIES

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**Table G.1 - Control Codes for Declared Plants in Western Australia**

| Priority | Requirements |
|---|---|
| P1<br>Prohibits movement | The movement of plants or their seeds is prohibited within the State. This prohibits the movement of contaminated machinery and produce including livestock and fodder. |
| P2<br>Aim is to eradicate infestation | Treat all plants to destroy and prevent propagation each year until no plants remain. The infested area must be managed in such a way that prevents the spread of seed or plant parts on or in livestock, fodder, grain, vehicles and/or machinery. |
| P3<br>Aims to control infestation by reducing area and/or density of infestation | The infested area must be managed in such a way that prevents the spread of seed or plant parts within and from the property on or in livestock, fodder, grain, vehicles and/or machinery.<br>Treat to destroy and prevent seed set for all plants:-<br>- Within 100 metres inside of the boundaries of the infestation.<br>- Within 50 metres of roads and high-water mark on waterways.<br>- Within 50 metres of sheds, stock yards and houses.<br>Treatment must be done prior to seed set each year.<br>Of the remaining infested area:-<br>- Where plant density is 1-10 per hectare treat 100% of infestation.<br>- Where plant density is 11-100 per hectare treat 50% of infestation.<br>- Where plant density is 101-1000 per hectare treat 10% of infestation.<br>Properties with less than 2 hectares of infestation must treat the entire infestation.<br>Additional areas may be ordered to be treated. |
| P4<br>Aims to prevent infestation spreading beyond existing boundaries of infestation | The infested area must be managed in such a way that prevents the spread of seed or plant parts within and from the property on or in livestock, fodder, grain, vehicles and/or machinery.<br>Treat to destroy and prevent seed s*et al*. l plants:-<br>- Within 100 metres inside of the boundaries of the infested property<br>- Within 50 metres of roads and high-water mark on waterways<br>- Within 50 metres of sheds, stock yards and houses<br>Treatment must be done prior to seed set each year. Properties with less than 2 hectares of infestation must treat the entire infestation.<br>Additional areas may be ordered to be treated.<br>Special considerations<br>In the case of P4 infestations where they continue across property boundaries there is no requirement to treat the relevant part of the property boundaries as long as the boundaries of the infestation as a whole are treated. There must be agreement between neighbours in relation to the treatment of these areas. |
| P5 | Infestations on public lands must be controlled. |

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# APPENDIX G LOCATION OF WEEDS RECORDED AT WEST ANGELAS

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| Taxon | Zone | Easting | Northing |
|---|---|---|---|
| *Acetosa vesicaria* | 50 | 670282 | 7439512 |
| *Bidens bipinnata* | 50 | 688661 | 7432669 |
| | 50 | 692404 | 7434579 |
| | 50 | 687622 | 7432995 |
| | 50 | 691478 | 7433848 |
| | 50 | 666551 | 7432511 |
| | 50 | 671795 | 7434819 |
| | 50 | 669588 | 7436085 |
| | 50 | 662967 | 7439466 |
| | 50 | 663340 | 7437261 |
| | 50 | 670256 | 7440041 |
| | 50 | 670827 | 7440121 |
| | 50 | 669629 | 7439904 |
| | 50 | 672747 | 7439755 |
| | 50 | 673669 | 7437233 |
| | 50 | 671233 | 7439484 |
| | 50 | 667450 | 7440007 |
| | 50 | 673420 | 7439350 |
| | 50 | 672580 | 7439183 |
| | 50 | 672525 | 7439032 |
| | 50 | 672930 | 7439386 |
| | 50 | 677143 | 7440336 |
| | 50 | 676777 | 7439888 |
| | 50 | 693252 | 7440857 |
| | 50 | 674804 | 7438827 |
| | 50 | 675187 | 7438908 |
| | 50 | 675043 | 7439279 |
| | 50 | 674566 | 7439117 |
| | 50 | 687534 | 7441102 |
| | 50 | 677807 | 7440841 |
| | 50 | 689733 | 7439848 |
| | 50 | 690405 | 7440055 |
| | 50 | 690919 | 7440001 |
| | 50 | 691442 | 7435304 |
| | 50 | 674380 | 7436772 |
| | 50 | 665892 | 7437188 |
| | 50 | 676625 | 7435967 |
| | 50 | 670111 | 7435914 |
| | 50 | 677184 | 7437539 |
| | 50 | 668923 | 7437248 |
| | 50 | 671181 | 7437165 |
| | 50 | 676037 | 7437964 |
| | 50 | 666346 | 7432772 |
| | 50 | 670282 | 7439512 |
| | 50 | 676538 | 7435978 |
| | 50 | 670245 | 7439842 |
| | 50 | 670290 | 7439432 |
| | 50 | 694470 | 7443294 |
| | 50 | 676131 | 7435725 |
| | 50 | 675457 | 7438797 |
| | 50 | 677339 | 7435770 |
| | 50 | 690693 | 7439991 |
| | 50 | 693338 | 7440912 |
| | 50 | 663126 | 7437338 |
| | 50 | 674534 | 7439138 |

| Taxon | Zone | Easting | Northing |
|---|---|---|---|
| | 50 | 671919 | 7439437 |
| *Bidens bipinnata* | 50 | 671996 | 7439530 |
| | 50 | 672245 | 7439314 |
| | 50 | 674681 | 7438937 |
| | 50 | 670797 | 7438950 |
| | 50 | 685963 | 7441614 |
| | 50 | 677188 | 7440257 |
| | 50 | 671144 | 7436941 |
| | 50 | 672760 | 7437834 |
| | 50 | 671976 | 7437503 |
| | 50 | 671876 | 7437376 |
| | 50 | 671720 | 7437424 |
| | 50 | 671667 | 7437390 |
| | 50 | 671508 | 7437270 |
| | 50 | 671595 | 7437248 |
| | 50 | 671643 | 7437271 |
| | 50 | 672628 | 7437571 |
| | 50 | 672742 | 7437635 |
| *Cenchrus ciliaris* | 50 | 676037 | 7437964 |
| *Cenchrus setiger* | 50 | 677095 | 7440194 |
| *Flaveria trinervia* | 50 | 671233 | 7439484 |
| | 50 | 677143 | 7440336 |
| *Malvastrum americanum* | 50 | 663340 | 7437261 |
| | 50 | 670827 | 7440121 |
| | 50 | 669629 | 7439904 |
| | 50 | 667450 | 7440007 |
| | 50 | 673420 | 7439350 |
| | 50 | 672930 | 7439386 |
| | 50 | 677143 | 7440336 |
| | 50 | 674804 | 7438827 |
| | 50 | 674566 | 7439117 |
| | 50 | 677807 | 7440841 |
| | 50 | 689733 | 7439848 |
| | 50 | 690919 | 7440001 |
| | 50 | 676037 | 7437964 |
| | 50 | 666346 | 7432772 |
| | 50 | 689097 | 7440761 |
| | 50 | 670282 | 7439512 |
| | 50 | 670290 | 7439432 |
| | 50 | 663126 | 7437338 |
| | 50 | 674534 | 7439138 |
| | 50 | 671919 | 7439409 |
| | 50 | 674681 | 7438937 |
| | 50 | 677245 | 7440321 |
| *Portulaca oleracea* | 50 | 687622 | 7432995 |
| | 50 | 668832 | 7436351 |
| | 50 | 662974 | 7436737 |
| | 50 | 669629 | 7439904 |
| | 50 | 673669 | 7437233 |
| | 50 | 671233 | 7439484 |
| | 50 | 672580 | 7439183 |
| | 50 | 694775 | 7442645 |
| | 50 | 677143 | 7440336 |
| | 50 | 674804 | 7438827 |
| | 50 | 675043 | 7439279 |
| | 50 | 687019 | 7440818 |

| Taxon | Zone | Easting | Northing |
|---|---|---|---|
| | 50 | 677807 | 7440841 |
| | 50 | 689733 | 7439848 |
| | 50 | 675036 | 7437340 |
| *Portulaca oleracea* | 50 | 676131 | 7435725 |
| | 50 | 687031 | 7441098 |
| *Sigesbeckia orientalis* | 50 | 665237 | 7437562 |
| | 50 | 687534 | 7441102 |
| | 50 | 694100 | 7441820 |
| | 50 | 691064 | 7441959 |
| *Vachellia farnesiana* | 50 | 677203 | 7437782 |
| | 50 | 674110 | 7437917 |

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# APPENDIX H SITE DESCRIPTIONS

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# APPENDIX I SPECIES X SITE MATRIX

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JANUARY 2014



*Providing sustainable environmental strategies,*
*management and monitoring solutions*
*to industry and government.*

ecologia
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# RIO TINTO IRON ORE
# GREATER WEST ANGELAS
# TERRESTRIAL FAUNA ASSESSMENT

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# RIO TINTO PTY LTD

# GREATER WEST ANGELAS

# TERRESTRIAL FAUNA ASSESSMENT

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| 0 | B. Greatwich | D. Cancilla | 20/01/13 | D. Cancilla | C. Nixon<br>T. Brown | 20/01/13 |

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# ACRONYMS

| | |
|---|---|
| **ARI** | Ashburton Regional Inventory |
| **BoM** | Bureau of Meteorology |
| **CAMBA** | China-Australia Migratory Bird Agreement |
| **DEC** | Department of Environment and Conservation |
| **DSEWPaC** | Department of Sustainability, Environment, Water, Population and Communities |
| **DPaW** | Department of Parks and Wildlife |
| **EIA** | Environmental Impact Assessment |
| **EPA** | Environmental Protection Authority |
| **EPBC Act** | *Environment Protection and Biodiversity Conservation Act 1999* |
| **JAMBA** | Japan-Australian Migratory Bird Agreement |
| **NHMRC** | National Health and Medical Research Centre |
| **PRI** | Pilbara Regional Inventory |
| **SAC** | Species Accumulation Curve |
| **SM2BAT** | SM2BAT+ 384 kHz ultrasonic acoustic recorder |
| **SRE** | Short Range Endemic |
| **WAM** | Western Australia Museum |
| **WC Act** | *Wildlife Conservation Act 1950* |

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# EXECUTIVE SUMMARY

Rio Tinto Iron Ore is currently conducting preliminary feasibility studies for the development of ore deposits C, D, D extension, G, F, H and Mt Ella, collectively termed the Greater West Angelas study area, located approximately 105 km north west of Newman. As part of these investigations, *ecologia* Environment was commissioned to conduct a two-phase vertebrate fauna and terrestrial invertebrate short-range endemic (SRE) survey of the study area. This survey will provide baseline data which may be supplemented with additional studies should approval to mine deposits be sought in the future.

The literature review identified that the potential vertebrate fauna assemblage consists of a total of 38 native and nine introduced mammal species, 129 bird species, 103 reptile species and eight amphibian species. Of these potential species, six mammal species, 12 bird species and three reptile species are listed as conservation significant. The literature review also identified 32 SRE species that have been previously recorded in the region surrounding the study area.

The survey was undertaken using a variety of sampling techniques, both systematic and opportunistic, in accordance with relevant guidelines. A summary of the vertebrate fauna survey effort consisted of;

- 12 trapping sites were open for 14 nights over two seasons, totalling 7,056 trapnights;
- 53.8 hours spent surveying for birds;
- 51.6 hours spent conducting diurnal searches;
- 25 hours spent conducting nocturnal searches;
- 576 hours of motion camera trapping; and,
- 340 hours of bat call recording analysis.

A summary of the invertebrate fauna survey effort consisted of:

- 12 sites consisting of dry pitfall and funnel traps were open for 14 nights, totalling 5,040 trapnights;
- 51.6 hours spent actively foraging (looking through leaf litter, under bark and stones etc); and
- A total of 60 leaf litter collections (1m$^2$ quadrat) taken from 18 locations.

A total of nine broad-scale habitat types have been identified within the study area; 'footslope or plain', 'hilltop, hillslope, ridge or cliff', 'mixed Acacia woodland', 'mesa top', 'cracking clay', 'major gorge and gully', 'major drainage', 'mulga woodland' and 'cleared area'. No habitats recorded were regarded as rare or unique to the study area.

A one-way ANOSIM test and MDS plot of the trapping sites within the different habitat types was completed for data collected systematically for both avifauna and terrestrial trapped fauna. The results from the one-way ANOSIM test suggested a slight difference between the habitats. The results of the MDS plot did not display visually a clear difference in habitat types for both avifauna and terrestrial trapped fauna. Overall, the results from the statistical habitat assessment suggested little difference in fauna assemblages between the different habitat types within the study area. This is likely due to the presence of a number of habitat generalist species recorded at many sites and in many habitats.

A total of 23 species of native mammal, two species of introduced mammal, 80 species of bird and 64 species of reptile were recorded during this survey. No species of amphibian were recorded.

The literature review identified 21 vertebrate fauna species of conservation significance as potentially occurring; six mammal species, 12 bird species and three reptile species. A total of six conservation significant species were recorded from the current survey, additionally, four species were assessed as having a high likelihood of occurrence with a further four species assessed as having a medium likelihood of occurrence. The remaining seven species were considered to have a low likelihood of occurrence.

The six species of conservation significance recorded from the study area consisted of; Pilbara Leaf-nosed Bat (Pilbara form) (EPBC VU, WC Act S1, DEC VU), Western Pebble-mound Mouse (secondary evidence only) (DEC P4), Fork-tailed Swift (EPBC M, WC Act S3), Australian Bustard (DEC P4), Bush Stone-curlew (signs only) (DEC P4) and Pilbara Barking Gecko (DEC P1).

A total of 33 invertebrate species from six different Orders were submitted for identification and SRE status assessment. Fifteen of these species were identified as potential SREs; two species of spider, one species of scorpion, six species of isopod, four species of pseudoscorpion and two species of centipede.

Systematically obtained data was assessed to determine survey adequacy through SACs. Extrapolation of the Michaelis-Menten (MM) curve suggested that 96.1% of trappable mammals, 92.1% of trappable reptiles, 98.5% of avifauna and 71.2% of SRE fauna had been recorded, indicating that the majority of fauna was recorded in all fauna groups.

When compared with previous surveys identified during the literature review, the current assessment recorded the highest number of mammal, bird and reptile species for the region. This is likely due to the size of the study area, variety of habitat types present and survey effort expended.

No significant limitations were experienced during the assessment. Given the minimal limitations experienced during the surveys and the fact that the majority of fauna species were recorded, the current assessment is considered adequate to allow assessment of impacts from future projects.

# 1 INTRODUCTION

## 1.1 PROJECT OVERVIEW

Rio Tinto Iron Ore (Rio Tinto) required biological surveys to be undertaken, in order to support a strategic assessment of the Greater West Angelas Project (the Project). The Project includes a series of iron ore deposits in the Pilbara region of Western Australia.

Rio Tinto is currently conducting preliminary feasibility studies for the development of ore deposits C, D, D extension, G, F, H and Mt Ella, collectively termed the Greater West Angelas study area (the study area) located approximately 105 km north-west of Newman (Figure 1.1). The study area comprises three separated areas covering a total of 175.65 $km^2$. The study area is situated on Rio Tinto exploration leases and encompasses the borefield supplying water to West Angelas mine. No pastoral leases intersect the study area.

As part of these investigations, *ecologia* Environment (*ecologia*) was commissioned to conduct a two-phase vertebrate fauna and terrestrial invertebrate short-range endemic (SRE) assessment of the study area. This survey will provide baseline data which may be supplemented with additional studies should approval to mine deposits be sought in the future.

## 1.2 LEGISLATIVE FRAMEWORK

The *Environmental Protection Act 1986* (EPBC Act) is "an Act to provide for an Environmental Protection Authority, for the prevention, control and abatement of environmental pollution, for the conservation, preservation, protection, enhancement and management of the environment and for matters incidental to or connected with the foregoing." Section 4A of this Act outlines five principles that are required to be addressed to ensure that the objectives of the Act are addressed. Three of these principles are relevant to native fauna and flora:

*The Precautionary Principle*

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

*The Principle of Intergenerational Equity*

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

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

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

In addition to these principles, projects undertaken as part of the Environmental Impact Assessment (EIA) process are required to address guidelines produced by the Environmental Protection Authority (EPA), in this case Guidance Statement No. 56: *Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia* (EPA 2004), principles outlined in EPA Position Statement No. 3: *Terrestrial Biological Surveys as an Element of Biodiversity Protection*(EPA 2002) and the *Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment, Guidance Statement 20: Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia* (EPA 2009).

In relation to terrestrial short range endemic (SRE) fauna, the EPA Guidance Statement *No. 56* states that:

> *"Comprehensive systematic reviews of different faunal groups often reveal the presence of short range endemic species (Harvey 2002). Among the terrestrial fauna there are numerous regions that possess short range endemics. Mountainous terrains and freshwater habitats often harbour short range endemics, but the widespread aridification and forest contraction that have occurred since the Miocene has resulted in the fragmentation of populations and the evolution of many new species. Particular attention should be given to these types of species in environmental impact assessment because habitat loss and degradation will further decrease their prospects for long-term survival."*

Harvey (2002) considered that although there were occasional SREs among the vertebrates and insects, there were much higher numbers among the molluscs, earthworms, some spider groups (especially the mygalomorphae), millipedes and some groups of crustaceans. SREs generally possessed similar ecological and life history characteristics, especially poor powers of dispersal, confinement to discontinuous habitats, slow growth, and low fecundity.

The State is committed to the principles and objectives for the protection of biodiversity as outlined in *The National Strategy for the Conservation of Australia's Biological Diversity* (Commonwealth Government 1996).

Native flora and fauna in Western Australia that are formally recognised as rare, threatened with extinction, or as having high conservation value are protected at a federal level under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and at a state level under the *Wildlife Conservation Act 1950* (WC Act).

The EPBC Act also takes into consideration four international agreements related to migratory species, which include the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention), the Japan-Australian Migratory Bird Agreement, the China-Australia Migratory Bird Agreement and the Republic of Korea-Australian Migratory Bird Agreement.

The EPBC Act was developed to provide for the protection of the environment, especially those aspects of the environment that are matters of national environmental significance, to promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources, and to promote the conservation of biodiversity. The EPBC Act includes provisions to protect native species (and in particular to prevent the extinction and promote the recovery of threatened species) and to ensure the conservation of migratory species. In addition to the principles outlined in Section 4A of the EPBC Act, Section 3A of the EPBC Act includes a principle of ecologically sustainable development dictating that decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations. Schedule 1 of the EPBC Act contains a list of species that are considered Extinct, Extinct in the Wild, Critically Endangered, Endangered, Vulnerable and Conservation Dependent. Definitions of categories relevant to fauna occurring or potentially occurring in the project area are provided in Appendix A.

The Western Australian *Wildlife Conservation Act 1950* (WC Act) provides for the conservation and protection of wildlife in Western Australia. Under Section 14 of this Act, all flora and fauna within Western Australia is protected; however, the Minister may, via a notice published in the *Government Gazette*, declare a list of fauna identified as rare, likely to become extinct, or otherwise in need of special protection (Appendix A). These species are considered Threatened Fauna. The current listing was gazetted in September 2013.

In addition, the Department of Parks and Wildlife (DPaW – formerly DEC) maintains a ranked list of specially protected fauna, which includes Threatened Fauna and Priority Fauna. These rankings dictate which species should receive the highest priority for conservation management. Threatened fauna that are listed as Schedule 1 under the WC Act are further ranked by the DPaW

according to their level of threat using IUCN Red List categories and criteria. Schedule 1 species can be ranked as Critically Endangered (CR), Endangered (EN) or Vulnerable (VU).

Priority Fauna are placed into five categories. The first three Priority Fauna categories are species that have not yet been adequately surveyed to be listed under Schedule 1 or 2, and are ranked in order of priority for survey and evaluation of conservation status so that consideration can be given to their declaration as threatened fauna. Species that are adequately known and are rare but not threatened, meet IUCN criteria for Near Threatened, or that have been recently removed from the threatened list for other than taxonomic reasons, are placed in Priority 4. These species require regular monitoring. Species meeting criteria for the IUCN category of Conservation Dependent are placed in Priority 5. The three Threatened Fauna codes and five Priority codes are also summarised in Appendix A.

Some better known SRE species have been listed as threatened or endangered under State or Commonwealth legislation in the WC Act and/or EPBC Act, but the majority have not. Often the lack of knowledge about these species precludes their consideration for listing as threatened or endangered. Listing under legislation should therefore not be the only conservation consideration in environmental impact assessment.

### 1.3 SURVEY OBJECTIVES

Rio Tinto commissioned *ecologia* Environment (*ecologia*) to undertake a comprehensive biological survey of the terrestrial vertebrate and invertebrate SRE fauna of the study area. This study will aid in supporting EIA of the project for future development.

The EPA's objectives with regards to fauna management are to:

- maintain the abundance, species diversity and geographical distribution of terrestrial fauna; and
- protect specially protected (Threatened) fauna, consistent with the provisions of the WC Act.

The aim of this study was to provide information to Rio Tinto and the EPA to assess the impact of the project on the fauna populations that occur in the regional areas associated with the project, thereby ensuring that these objectives will be upheld.

This report satisfies the requirements documented in relevant EPA guidelines, by providing:

- a review of background information (including literature and database searches);
- an inventory of vertebrate and invertebrate fauna species occurring in the study area, incorporating recent published and unpublished records;
- a discussion related to the species of biological and conservation significance recorded or likely to occur within the study area and the surrounding region;
- a description of fauna habitats occurring in the study area;
- a description of the characteristics of the faunal assemblage;
- an appraisal of the current knowledge base for the area, including a review of previous surveys conducted in the area that are relevant to the current study; and
- a review of regional and biogeographical significance, including the conservation status of species recorded in the study area.

## 1.4 BACKGROUND SUMMARY OF FAUNA GROUPS

### 1.4.1 Vertebrate Conservation Significant Species

Australia's vertebrate fauna, in particular mammal and bird species, have experienced a high rate of decline and extinction over the last two hundred years (Johnson 2006), with approximately thirty species of mammals and birds becoming extinct and a further 57 species of mammals, birds, reptiles, frogs and fish, many hundreds of species of invertebrate considered endangered and likely to become extinct in near future.

Changes in fire regime and the introduction of feral animals, such as the Fox and the Cat resulted in a decrease and the extinction of several species. A number of ground dwelling birds, such as the Night Parrot and the Ground Parrot, and small to medium sized mammals (Lesser Bilby and Greater Stick-nest Rat) have reduced drastically in numbers or even became extinct. With the onset of progressively more impact by human activity, already rare fauna species that are generally restricted to a particular habitat or microhabitat, are identified and protected to preserve the existing populations within their habitat.

### 1.4.2 Terrestrial Invertebrate Short Range Endemics

The decline in biodiversity of terrestrial communities has already been observed both nationally and state-wide (CALM 2004). There is also an increasing shift in environmental protection from species based conservation to biodiversity based conservation (Chessman 1995; Burbidge *et al.* 2000; McKenzie *et al.* 2000) and one of the important considerations involved in this is the presence of endemic species.

Endemism refers to the restriction of species to a particular area, whether it is at the continental, national or local level (Allen *et al.* 2002). This review focuses on SREs, outlines the major paths to short range endemism, the current knowledge of short range endemism in Australia and the conservation significance of such species. It is important to note that the individual taxa and broader groups discussed are not an exhaustive list of all SREs. This is due to the fact that SRE are dominated by invertebrate species, which are historically understudied and in many cases lack formal descriptions. An extensive, reliable taxonomic evaluation of these species has begun only relatively recently and thus the availability of literature relevant to SREs is relatively scarce.

### 1.4.3 Processes Promoting Short Range Endemism

Short range endemism is influenced by numerous processes, which generally contribute to the isolation of a species. A number of factors, including the ability and opportunity to disperse, life history, physiology, habitat requirements, habitat availability, biotic and abiotic interactions, and historical conditions, influence not only the distribution of a taxon, but also the tendency for differentiation and speciation (Ponder and Colgan 2002).

Isolated populations of plants and animals tend to differentiate both morphologically and genetically as they are influenced by different selective pressures over time. Additionally, a combination of novel mutations and genetic drift promote the accumulation of genetic differences between isolated populations. Conversely, the maintenance of genetic similarity is promoted by a lack of isolation through migration between the populations, repeated mutation and balancing selection (Wright 1943). The level of differentiation and speciation between populations is determined by the relative magnitude of these factors, with the extent of migration generally being the strongest determinant. Migration is hindered by the poor dispersal ability of the taxon as well as geographical barriers to impede dispersal. In summary, those taxa that exhibit short range endemism are generally characterised by poor dispersal, low growth rates, low fecundity and reliance on habitat types that are discontinuous (Harvey 2002).

The historical connections between habitats are also important in determining species distributions and often explain patterns that are otherwise inexplicable by current conditions. Many SREs are considered to be relictual taxa (remnants of species that have become extinct elsewhere) and are confined to certain habitats, and in some cases, single geographic areas (Main 1996). Relictual taxa include extremely old species that can be traced back to the Gondwanan periods (180-65 million years ago) and have a very restrictive biology (Harvey 2002).

In Western Australia, relictual taxa generally occur in fragmented populations, from lineages reaching back to historically wetter periods. For example, during the Miocene period (from 25 million to 13 million years ago), the aridification of Australia resulted in the contraction of many areas of moist habitat and the fragmentation of populations of fauna occurring in these areas (Hill 1994). With the onset of progressively dryer and more seasonal climatic conditions since this time, suitable habitats have become increasingly fragmented. Relictual species now generally persist in habitats characterised by permanent moisture and shade, maintained by high rainfall and/or prevalence of fog. This may be induced by topography or coastal proximity, or areas associated with freshwater courses (e.g. swamps or swampy headwaters of river systems), caves or microhabitats associated with southern slopes of hills and ranges, rocky outcrops, deep litter beds or various combinations of these features (Main 1996; Main 1999). As a result, these habitats support only small, spatially isolated populations, which are further restricted by their low dispersal powers typical for all SRE species.

### 1.4.4 Taxonomic Groups Likely to Support Short Range Endemism

**Arachnids (Phylum: Arthropoda, Sub Class: Arachnida)**

Four orders of arachnids can exhibit short range endemism: Pseudoscorpiones (false scorpions), Scorpiones (true scorpions), Schizomida (short-tailed whip spiders) and Araneae (i.e. infraorder: Mygalomorphae or trap-door spiders). Many mygalomorph trap-door spider species are vulnerable to disturbance and exhibit short range endemism due to their limited ability to disperse. These spiders also have extreme longevity and the long-term persistence of females in a single burrow (Raven 1982). Mygalomorph spiders are largely considered 'old world' spiders and, as such, are generally adapted to past climatic regimes making them vulnerable to desiccation in arid environments. They use a variety of behavioural techniques to avoid desiccation, the most obvious of which is their burrow, which may reach up to 70 cm in depth (Main 1982). Mygalomorph groups are thus capable of surviving on the periphery of the great central desert region and minor habitats within the general arid regions of the continent. Many mygalomorph spider species are known from the Pilbara region with representatives of the families Nemesiidae, Barychelidae, Actinopidae, Idiopidae, Dipluridae and Ctenizidae and several potential SRE mygalomorph species known from nearby locations to the study area.

Another member of the arachnid class, the Schizomida, is comprised entirely of SREs, with most recorded from single localities (Harvey 2002).Forty-six schizomid species have been described in northern Australia. Most are known to occur in the entrances to and inside caves, while the remainder occur in nearby habitats (Harvey 2002). No epigean schizomids are known from the Pilbara region (Harvey *et al.* 2008).

Scorpions and pseudoscorpions also exhibit high degrees of endemism (Koch 1981; Harvey 1996). Scorpions are popularly thought of as desert animals although they can be found in most of Australia's climatic zones. Several SRE scorpions and pseudoscorpions are known from the Pilbara region including species from the scorpion genera *Lychas* and *Urodacus* and the pseudoscorpion species *Synsphyronus gracilis*.

**Millipedes and Centipedes (Phylum Arthropoda, Class Myriapoda)**

Despite millipedes being highly abundant in soil and leaf litter and highly diverse at the order level, they are inadequately studied and relatively little is known of their biogeography (Harvey 2002). SRE millipedes known to occur in the Goldfields include species from the genus *Antichiropus*. All species from this genus are known to be short range endemics with the exception of two species *Antichiropis variabilis* and *Antichiropus*'PM1', from the jarrah forests and northern Wheatbelt respectively. This genus extends from the Nullarbor Plain to the Pilbara region.

Centipedes are not listed by Harvey (2002) as SRE species; however they have been shown to be endemic to small areas on the east coast (Edgecombe *et al.* 2002). Examination of the distributions of species featured in the CSIRO centipede webpage also reveals disjunct and isolated occurrences of many species. A number of genera have Pangaean and Gondwanan affinities (Edgecombe *et al.* 2002). In general, these animals have a relatively cryptic biology, preferring moist habitats in deep litter accumulations, under rocks and in rotting logs, and they have relatively poor dispersal abilities (Lewis 1981). This suggests that they are potential candidates for designation as SREs.

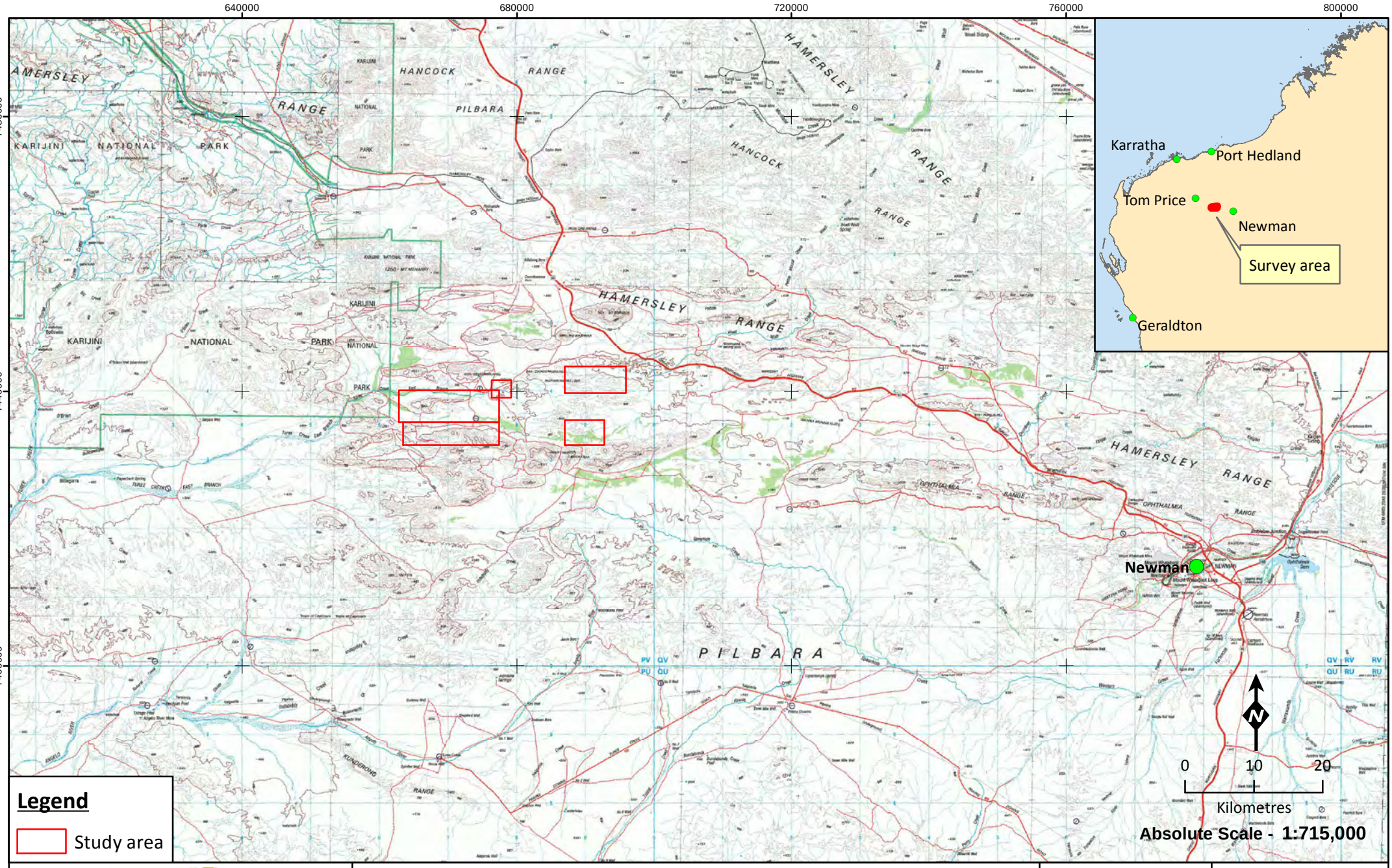
**Molluscs (Phylum: Mollusca)**

Numerous species of freshwater and terrestrial molluscs belonging to many genera have been identified in Australia, with most being SREs (Harvey 2002). Restricted ranges of the terrestrial molluscs of the drier northern and western Australia were noted for a vast number of species (Solem 1997). Among these were seven endemic species of *Rhagada* from the Dampier Archipelago, five of which were found to occur sympatrically on one island. However, in a recent genetic study conducted on *Rhagada* (Johnson *et al.* 2004), allozyme analysis revealed little variation between taxa. Such a finding could indicate that there is merely high morphological diversity within one or a few species. It is also possible however, that there is a number of highly endemic species and that morphological diversity has taken place rapidly with little genetic change (Johnson *et al.* 2004).

Some species of the terrestrial snail genera *Bothriembryon* are known to be SREs. Species of these genera have been recorded within the Pilbara region with some occurring in areas close to the study area.

**Worms (Phylum: Annelida & Onychophora)**

The taxonomic status of the earthworm family, Megascolecidae, in Western Australia was revised by Jamieson in 1971. As a result of this study, it was concluded that most of the earthworm genera are made up almost entirely of SREs (Harvey 2002). This is also the case with the velvet worms (Onychophorans). Due to several taxonomic revisions that have been conducted (see references within Harvey, 2002), the number of onychophoran species has expanded from six to over 70 species, and a number of species still remain undescribed (Harvey 2002). Very few of these species exceed ranges of 200 $km^2$ and some are restricted to single localities and have high genetic differentiation, indicating very little mobility and dependence on their permanently moist habitats (Harvey 2002). No terrestrial SRE worms are known from the Pilbara region.




ecologia ENVIRONMENT

# Location of Study area

**Figure: 1.1**
**Project ID: 1458**

**Drawn:BG**
**Date: 13/02/2013**

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

Unique Map ID: BG309

**A4**

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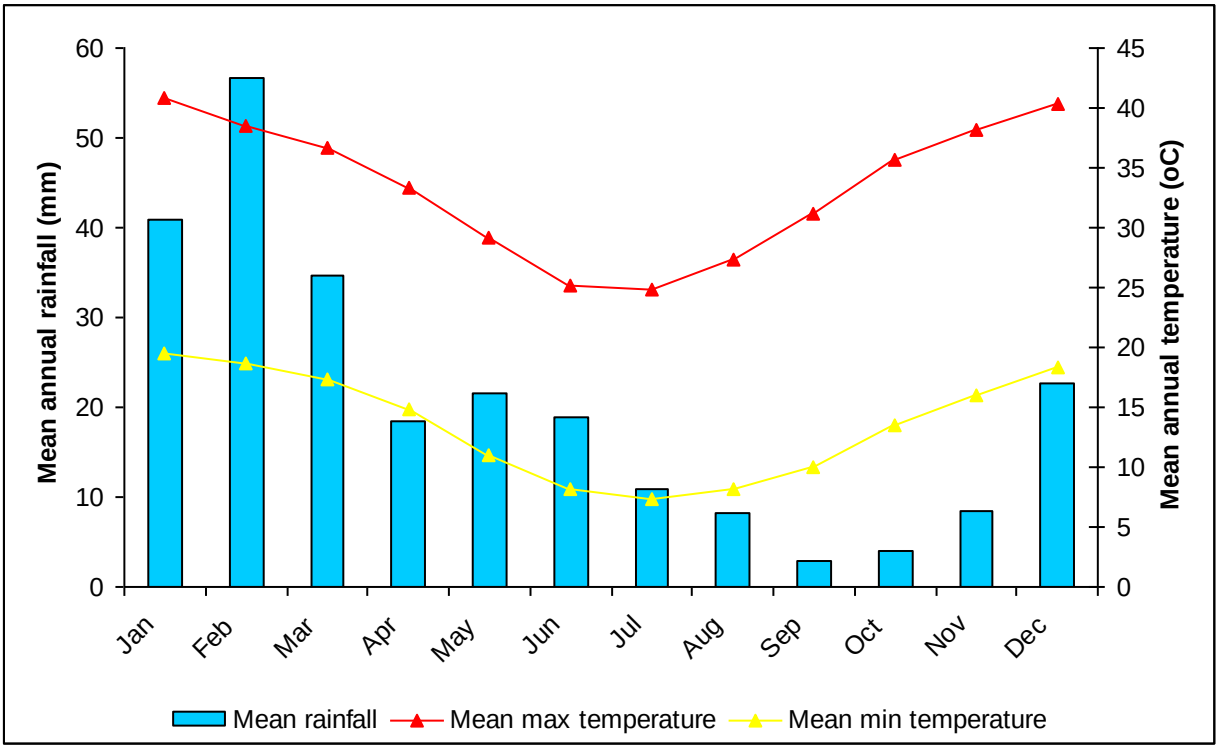
# 2 EXISTING ENVIRONMENT

## 2.1 CLIMATE AND WEATHER

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

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

The nearest Bureau of Meteorology (BOM) station that has current temperature data is Paraburdoo Aero (Site No. 007185), 85 km west from the western boundary of the study area. Rainfall data is available from Turee Creek Station (Site No 007083) located 45.5 km south of the southern boundary of the study area. The study area location has a typical Pilbara climate of hot summers with sporadic summer storms and warm dry winters (BoM 2013). Figure 2.1 displays monthly rainfall and temperature averages with temperatures obtained from Paraburdoo Aero, rainfall obtained from Turee Creek Station.




Source: BOM (2013)

**Figure 2.1 – Mean monthly climate data**

An indication of weather experienced during the survey is shown in Appendix B. Phase 1 experienced typical early spring conditions, with daily maximum temperatures ranging from 28.2°C to 38.1°C (average 34.1°C) and daily minimums ranging from 11.4°C to 20.2°C (average 16.4°C). No rainfall was received during the survey.

Phase 2 experienced warmer conditions, with above average rainfall for the region experienced leading up to Phase 2. During the months of December 2012 and January 2013, a total of 185.2 mm of rain were received at Turee Creek Station (Site No 007083, (BoM 2013). No rainfall was recorded from Turee Creek Station during the survey period (Appendix B). Localised thunderstorms and associated heavy rainfall occurred on a number of days within the study area. The maximum temperature reached 43.1°C on the second day of surveying with an average of 39.6°C. The daily mimimum temperature ranged from 18.7°C to 31.4°C, averaging 24.5°C (BoM 2013, Appendix B).

## 2.2 BIOGEOGRAPHY

The Interim Biogeographic Regionalisation for Australia (IBRA) classifies the Australian continent into regions (bioregions) of similar geology, landform, vegetation, fauna and climate characteristics (DEWHA 2004). According to IBRA Version 7 (DSEWPaC 2012), the study area lies within the Pilbara Bioregion which comprises four subregions: Hamersley, Fortescue Plains, Chichester and Roebourne.

The study area lies within the Hamersley subregion (Figure 2.2) which in turn encompasses 6,215,092 ha of the southern section of the Pilbara Craton. It is composed of mountainous areas of Proterozoic sedimentary ranges and plateaus, dissected by gorges (basalt, shale and dolerite). General vegetation types include Mulga low woodland over bunch grasses on fine textured soils in valley floors, and *Eucalyptus leucophloia* over *Triodia brizoides* occur on the skeletal soils of the ranges. The climate is Semi-desert tropical, with an average 300 mm rainfall, usually in summer cyclonic or thunderstorm events. Winter rain is not uncommon. Drainage flows into either the Fortescue (to the north), the Ashburton to the south, or the Robe to the west (Kendrick and McKenzie 2001).

## 2.3 LAND SYSTEMS

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

Seven land systems mapped by Payne *et al* (1982) within the ARI and by Van Vreeswyk *et al*. (2004) in the PRI are present within the study area, each of which has been further classified by landform, soil, vegetation and drainage patterns. The seven land systems within the study area include Boolgeeda, Egerton, Elimunna, Newman, Platform, Rocklea and Wannamunna, with the Newman (71.4 $km^2$) and Boolgeeda (56.2 $km^2$) land systems being the most extensive. Summary descriptions of the characteristics of each land system are provided in Table 2.1, with land systems of the study area mapped in Figure 2.3.

The condition of the vegetation of each land system within the ARI and PRI has also been assessed. Regionally the majority of the area within each of these land systems has been determined to be in very good condition due to inaccessibility and lack of palatable vegetation. The Elimunna and

Wannamunna Land Systems are the exception, with only 39% and 44%, respectively characterised to be in good or very good condition. The remaining 17% has been determined to be in fair, poor or very poor condition. The condition of both land systems is due to the presence of vegetation that is attractive to grazing animals and prone to degradation if grazing pressure is excessive. The Wannamunna Land System is regionally restricted, comprising only 0.22% of the combined ARI and PRI areas surveyed by Payne *et al* (1982) and Van Vreeswyk *et al*. (2004). Within the study area it is also restricted, comprising only 0.3% of the total area. The area of each land system within the study area represents less than one percent of their individual regional distribution.

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

**Table 2.1 – Land System information from the study area**

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

| Land System (% of study area) | Area (% of PRI and ARI combined) | Area within study area (% of Land System) | Description | Vegetation Condition Assessment | Landform (and % of Land System) | Vegetation Community |
|---|---|---|---|---|---|---|
| **Elimunna** (1.15%) | 656.6 km$^2$ (0.24%) | 2.0 km2 (0.30%) | Stony plains on basalts supporting sparse *Acacia* and cassia shrublands and patchy tussock grasslands. | Very good 14%, good 25%, fair 35%, poor 21%., very poor, 5% Vegetation attractive to grazing animals and prone to degradation if grazing pressure is excessive. | Hills and low rises (10%) | Hummock grasslands of *Triodia wiseana* (hard spinifex) or very scattered shrublands of *Acacia* and *Senna* spp. |
| | | | | | Stony plains (45%) | Very scattered to scattered mixed height shrublands with *Acacia aneura* (mulga) other *Acacia*s, *Senna* spp. (cassias) and *Eremophila* spp. occasionally with patchy *Triodia* spp. (hard spinifex) understorey. |
| | | | | | Gilgai plains (26%) | Patchy tussock grasslands with *Eragrostis xerophila* (Roebourne Plains grass), *E. setifolia* (neverfail), *Astrebla pectinata* (barley Mitchell grass) with isolated shrubs mainly *Eremophila* and *Senna* spp. |
| | | | | | Hardpan plains (6%) | Very scattered tall shrublands of *A. aneura* and other *Acacia*s. |
| | | | | | Groves (1%) | Moderately close to close tall shrublands of *A. aneura* with numerous other shrubs and patchy perennial grasses. |
| | | | | | Drainage floors (12%) | Tussock grasslands with *Astrebla* and *Eragrostis* spp. Or very scattered to moderately close tall shrublands of *Acacia* spp. With various low shrubs and patchy tussock and/or hummock grasses. |
| **Newman** (40.66%) | 21109 km$^2$ (7.7%) | 71.4 km$^2$ (0.34%) | Rugged jaspilite plateaux, ridges and mountains supporting hard. | Very good 91%, good 7%, fair 1%, poor 1%. Inaccessible or poorly accessible and is unsuitable for pastoral purposes. | Plateaux, ridges, mountains and hills (70%) | Hummock grasslands of *Triodia wiseana*, *T. brizoides*, *T. plurinervata* with very scattered to scattered shrubs and trees including *Acacia* and *Senna* spp., *Grevillea wickhamii*, *Eucalyptus leucophloia* and other eucalypts. Occasionally hummock grass is *Triodia biflora*. |
| | | | | | Lower slopes (20%) | Similar to the vegetation community above. |
| | | | | | Stony plains (5%) | Hummock grasslands of *Triodia wiseana*, *T.* spp. (hard spinifex) with isolated to very scattered shrubs of *Acacia* and *Senna* spp. And occasional eucalypt trees. Occasionally hummock grasslands of *Triodia pungens* (soft spinifex). |
| | | | | | Narrow drainage floors with channels (5%) | Smaller floors support hummock grassland of *Triodia pungens* with very scattered shrubs. Larger floors and channel support tall shrublands/woodlands of *Acacia* spp. And *Eucalyptus victrix* with tussock grass or hummock grass understoreys. |

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

## 2.4 VEGETATION

The vegetation of Western Australia was originally mapped at the 1:1,000,000 scale by Beard (1979), and was subsequently reinterpreted and updated to reflect the National Vegetation Information System standards (Shepherd *et al.* 2002). The study area lies within the Eremaean Botanical Province (Beard 1975). Two vegetation associations occur in the study area (Shepherd *et al.* 2001), and are described in Table 2.2 and displayed in Figure 2.4.

**Table 2.2 – Vegetation associations of the study area**

| Shepherd Unit | Structure | Vegetation Description | Species | Area within the study area ($km^2$) | Percentage of the study area (%) |
|---|---|---|---|---|---|
| 18 | Low woodland; mulga (*Acacia aneura*) | *Acacia* open shrubland / *Ptilotus* mixed open forbland | *Acacia aneura*, *Acacia pruinocarpa*, *Acacia aneura* var. *Aneura, Eremophila fraseri*, *Eremophila foliosissima*, *Eremophila exilifolia, Senna* sp., *Solanum lasiophyllum*, *Ptilotus obovatus*. | 89.5 | 51 |
| 82 | Open hummock grassland | Hummock grasslands, low tree steppe; snappy gum over *Triodia wiseana* | *Eucalyptus leucophloia*, *Eucalyptus gamophylla*, *Senna artemisioides subsp.* x *sturtii*, *Dodonaea viscosa*, *Grevillea wickhamii*, *Triodia wiseana*, *Ptilotus rotundifolius*, *Acacia lycopodiifolia* and *Triodia wiseana*. | 86.2 | 49 |

## 2.5 GEOLOGY

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

The main source of the magnetic mineralization in the Pilbara is the Pincunah Formation, which is one of the prominent Banded Ironstone Formations (BIF) within the greenstone belts of the Pilbara Craton. The study area is intersected by three different geological formations: Mafic volcanics, Sedimentary Rocks and Dolerites and gabbros from the Archaean to Palaeoproterozoic era. The study area and local geology is presented in Figure 2.5. Definitions of the geological unit codes are provided in Table 2.3 (Hickman and Kranendonk 2008). Geology of the study area comprises 12.4% mafic volcanics, 66.4% sedimentary rock and 21.1% dolerites and gabbros geological units (Hickman and Kranendonk 2008).

**Table 2.3 – Geology of the study area**

| Geological Code | Lith Association | Area within study area ($km^2$) | Definition of code |
|---|---|---|---|
| A4 - -Pp | Mafic volcanics | 21.7 | Archaean period |
| A3b | Sedimentary rocks | 116.9 | Archaean – palaeoproterozoic period |
| A2d | Dolerites and gabbros | 37.0 | Archaean period |

## 2.6 SOILS

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

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

Within the study area, three soil units as classified by Bettenay *et al.* occur (Figure 2.6). These units are described below:

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

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

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

## 2.7 LITERATURE REVIEW

Several databases were consulted in the preparation of potential fauna (and conservation significant fauna) lists (Table 2.4). In addition, ecologia has conducted 18 surveys within 70 km of the study area, with a further eight publications, reporting on fauna surveys conducted in the same region, also consulted (Table 2.5). The location of previous surveys in relation to the study area is shown in Figure 2.7. The results of database searches and previous surveys for vertebrate and SRE fauna are presented in Appendix E. The online NatureMap database encompasses several datasets which include the WA Museum (WAM), DEC threatened fauna database and DEC survey return database.

The literature review has revealed that the potential vertebrate fauna assemblage consists of a total of 38 native and nine introduced mammal species, 129 bird species, 103 reptile species and eight amphibian species have the potential to occur within the study area (Appendix F). Of these potential

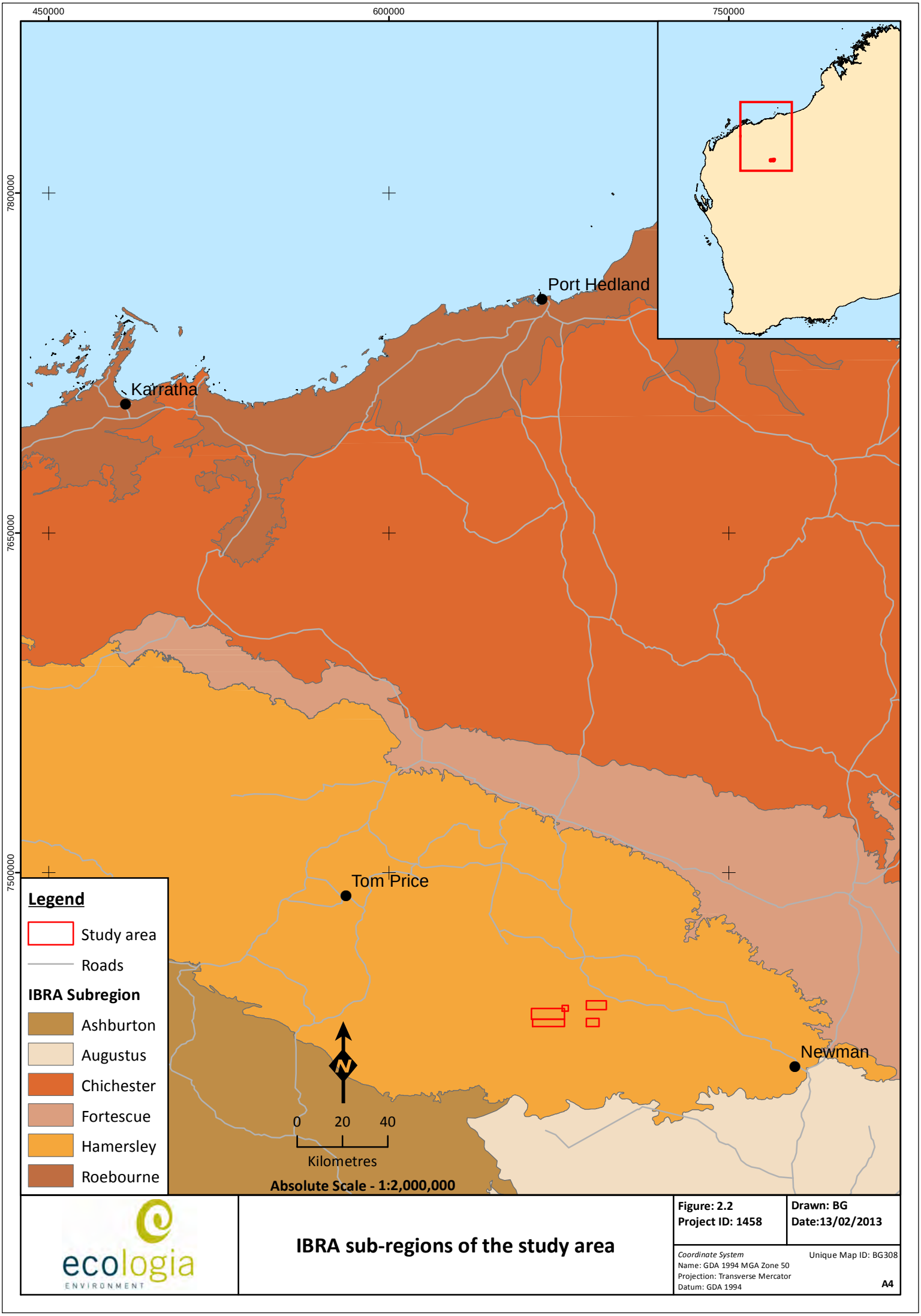
species, six mammal species, 12 bird species and three reptile species are listed as conservation significant. These are discussed in detail in section 5.3. The literature review revealed 32 SRE species have been previously recorded in the region (Appendix F).

**Table 2.4 – Fauna databases searched to determine the potential vertebrate fauna assemblage**

| Database | Custodian | Search Details |
|---|---|---|
| NatureMap | DEC | Records within 40 km of study area |
| Threatened fauna search | DEC | Records within 40 km of study area |
| Protected Matters Search Tool | Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) | Records within 40 km of study area |
| Birdata | BirdLife Australia | Records within 100 km of the study area |
| Arachnid database | WAM | Records within 50 km of study area |
| Crustacea database | WAM | Records within 50 km of study area |
| Molluscs database | WAM | Records within 50 km of study area |

**Table 2.5 – Previous biological survey reports within 70 km of the study area**

| Survey Location and Author(s) | Distance to Project Area (km) | Comments |
|---|---|---|
| **Vertebrate fauna** | | |
| *ecologia* internal database | 0 – 50 | Total of 14 surveys consisting of seven Level 2 surveys and seven Level 1 surveys |
| A vertebrate fauna survey of the proposed Hope Downs 4 Option 6 infrastructure corridor (Ninox 2009b) | 30 | Level 2 survey |
| Vertebrate fauna of the northern transport corridor option (Ninox 1995) | 35 | Level 1 survey |
| Marillana Creek Western Access Corridor - Biological Assessment (HGM 1999b) | 35 | Level 1 survey |
| Marillana Creek Iron Ore Project - Review of Biological Reporting (HGM 1999a) | 45 | Level 1 survey |
| Yandi Life of Mine Flora and Fauna (Maunsell 2003) | 45 | Level 1 survey |
| A fauna survey of the proposed Hope Downs 4 mining area (Ninox 2009a) | 65 | Level 2 survey |
| Vertebrate fauna of the proposed Junction Deposit mine and the central Pilbara transport corridor (Ninox 1994) | 50 | Level 1 survey |
| Yandicoogina Junction South West and Oxbow Fauna Survey (Biota 2010) | 50 | Level 2 survey |
| **Invertebrate fauna** | | |
| *ecologia* internal database | 30 - 70 | Total of four surveys |
| Yandicoogina Junction South West and Oxbow Fauna Survey (Biota 2010) | 50 | Pitfall traps and foraging |
| A fauna survey of the proposed Hope Downs 4 mining area (Ninox 2009a) | 65 | Foraging and leaf litter sorting |




ecologia ENVIRONMENT

# IBRA sub-regions of the study area

| | |
|---|---|
| **Figure: 2.2** | **Drawn: BG** |
| **Project ID: 1458** | **Date:13/02/2013** |

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

Unique Map ID: BG308

**A4**

665000 670000 675000 680000 685000 690000 695000

7445000
7440000
7435000
7430000

Jamindie Land System

Wannamunna Land System

Deposit I

Deposit H

Egerton Land System

Deposit B

Deposit G

Platform Land System

Deposit C

Rocklea Land System

Elimunna Land System

Deposit D

Spearhole Land System

Deposit A

Deposit F

Boolgeeda Land System

Mt Ella

Deposit E

Newman Land System

N

**Legend**

Study area

Deposit area

0 2 4

Kilometres

**Absolute Scale - 1:90,000**

Pindering Land System

ecologia ENVIRONMENT

# Landsystems of the study area

**Figure: 2.3**
**Project ID: 1458**

**Drawn: BG**
**Date: 12/2/2013**

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

Unique Map ID: BG310

**A3**

665000 670000 675000 680000 685000 690000 695000

7445000 7440000 7435000 7430000

82 29 Deposit I Deposit B Deposit H Deposit G 18 Deposit C Deposit D Mt Ella Deposit A Deposit F Deposit E

N

0 2.5 5

Kilometres

**Absolute Scale - 1:90,000**

**Legend**

Study area

Deposit area

ecologia ENVIRONMENT

# Vegetation units of the study area

**Figure: 2.4**
**Project ID: 1458**

**Drawn: BG**
**Date: 12/2/2013**

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

Unique Map ID: BG286

**A3**

665000 670000 675000 680000 685000 690000 695000

7445000

7440000

7435000

7430000

Deposit I

Deposit G

Deposit B

A3b

Deposit H

A2d

Deposit C

Deposit D

Mt Ella

Deposit A

Deposit F

Deposit E

A4 - -Pp

A4 - -Pp

A2d

N

0 2.5 5

Kilometres

**Absolute Scale - 1:90,000**

**Legend**

Study area

Deposit area

ecologia ENVIRONMENT

# Geology of the study area

**Figure: 2.5**
**Project ID: 1458**

**Drawn: BG**
**Date: 12/2/2013**

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

Unique Map ID: BG280

**A3**

665000 670000 675000 680000 685000 690000 695000

7445000 7440000 7435000 7430000

Fa13

Fa14

Deposit I

Deposit B

Deposit H

Deposit G

Fa13

Fb3

Deposit C

Deposit D

Fa14

Mt Ella

Deposit A

Deposit F

Deposit E

Fa13

Fb3

N

0 2.5 5

Kilometres

**Absolute Scale - 1:90,000**

**Legend**

Study area

Deposit area

ecologia ENVIRONMENT

# Soils of the study area

**Figure: 2.6**
**Project ID: 1458**

**Drawn: BG**
**Date: 12/2/2013**

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

Unique Map ID: BG278

**A3**

700000

800000

7500000

HGM 1999b

Maunsell 2003

Ninox 1994

Biota 2010

HGM 1999a

Ninox 1995

Ninox 2009b

Ninox 2009a

Newman

0 10 20

Kilometres

**Absolute Scale - 1:500,000**

## Legend

- *ecologia* (SRE)
- *ecologia* (vertebrate fauna L1)
- *ecologia* (vertebrate fauna L2)
- other company
- Study area

ecologia ENVIRONMENT

# Previous survey locations

**Figure: 2.7**
**Project ID: 1458**

**Drawn: BG**
**Date: 26/2/2013**

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

Unique Map ID: BG287

**A3**

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# 3 METHODOLOGY

## 3.1 DETERMINATION OF SURVEY SAMPLING DESIGN AND INTENSITY

Prior to the development of field survey methodologies, a review was undertaken of factors likely to influence survey design and intensity (EPA 2004) (Table 3.1). Based on this review, it was deemed necessary for a Level 2 survey to be conducted within the study area.

**Table 3.1 – Factors likely to influence survey design**

| Factor | Relevance |
|---|---|
| Bioregion – level of existing survey-knowledge of the region and associated ability to predict accurately. | A sound level of previous survey effort and knowledge exists. A total of 26 previous surveys within 70 km have been reviewed. The Hamersley sub-region of the Pilbara has been relatively well studied. |
| Landform special characteristics/specific fauna/specific context of the landform characteristics and their distribution and rarity in the region. | The study area lies within the Hamersley sub-region and contains typical habitat of the surrounding region. A large area of Mulga woodland habitat type occurs in the south-east of the study area. |
| Lifeforms, life cycles, types of assemblages and seasonality (e.g. migration) of species likely to be present. | A two-phase survey during spring and autumn with survey timing consistent with survey guidelines. |
| Level of existing knowledge and results of previous regional sampling (e.g. species accumulation curves, species/area curves). | A large number of previous surveys in the region, with a total of 26 previous surveys within 70 km have been reviewed. |
| Number of different habitats or degree of similarity between habitats within a study area. | Nine broad-scale habitats have been assessed as occurring within the study area. The Cracking Clay habitat associated with Elimunna landsystem is a restricted habitat type of the region. All other habitats occur broadly in the surrounding region. The Mulga woodland habitat is of high quality. |
| Climatic constraints (e.g. temperature or rainfall that preclude certain sampling methods). | Climatic conditions were typical for the time of year. |
| Sensitivity of the environment to the proposed activities. | The Cracking Clay habitat associated with Elimunna landsystem has been previously assessed as environmentally sensitive to degradation. The Mulga woodland habitat is of high quality. Other habitats are widespread in the surrounding region. |
| Size, shape and location of the proposed activities. | The study area comprises three separated areas covering a total of 175.65 $km^2$ |
| Scale and impact of the proposal. | Not applicable as no assessment can be made at this stage as no defined impact areas are determined as yet. |

## 3.2 SURVEY TIMING

The two phase Level 2 survey was conducted during spring 2012 and autumn 2013 (Table 3.2). Survey timing was determined as per guidelines (EPA 2004; EPA and DEC 2010).

**Table 3.2 – Summary of survey timing and duration**

| Survey | Timing | Duration (days) | Person Days |
|---|---|---|---|
| Phase 1 | 26/09/2012 – 06/10/2012 | 11 | 74 |
| Phase 2 | 18/03/2013 – 27/03/2013 | 10 | 60 |
| **Total** | | **21** | **134** |

## 3.3 SITE SELECTION

Terrestrial fauna survey sites were selected to provide a good geographic spread over the study area and to be representative of the habitat types in the study area, with location of currently identified deposits taken into consideration. Habitat types occurring over a larger proportion of the study area were sampled using a larger number of trapping sites than less represented habitat types. Habitat types poorly represented by systematic sampling sites were further surveyed using opportunistic searches, targeting potentially sensitive habitats and habitats likely to support conservation significant species. Locations and details of all fauna survey sites are listed in Table 3.3 and mapped in Figure 3.1.

Descriptions and photographs of the systematic fauna trapping sites can be found in Appendix C.

**Table 3.3 – Survey site locations**

| Site | Location | |
|---|---|---|
| | Easting | Northing |
| **Systematic trap site** | | |
| GWA S1 | 690650 | 7441655 |
| GWA S2 | 691892 | 7441631 |
| GWA S3 | 687325 | 7432923 |
| GWA S4 | 690271 | 7434157 |
| GWA S5 | 675012 | 7434694 |
| GWA S6 | 668071 | 7434246 |
| GWA S7 | 666240 | 7436475 |
| GWA S8 | 673177 | 7437814 |
| GWA S9 | 688109 | 7440440 |
| GWA S10 | 671504 | 7435248 |
| GWA S11 | 673158 | 7438238 |
| GWA S12 | 667740 | 7439331 |
| **Opportunistic search site** | | |
| GWA Opp S1 | 666513 | 7436849 |
| GWA Opp S2 | 672777 | 7433992 |
| GWA Opp S3 | 668377 | 7434089 |
| GWA Opp S4 | 673142 | 7439083 |
| GWA Opp S5 | 666358 | 7432530 |
| GWA Opp S6 | 672027 | 7439426 |
| GWA Opp S7 | 673911 | 7433876 |
| GWA Opp S8 | 687382 | 7434157 |
| GWA Opp S9 | 690830 | 7441558 |
| GWA Opp S10 | 690386 | 7434554 |
| GWA Opp S11 | 662985 | 7439744 |
| GWA Opp S12 | 669725 | 7439306 |
| GWA Opp S13 | 688095 | 7440343 |
| GWA Opp S14 | 672883 | 7439043 |
| GWA Opp S15 | 689013 | 7434085 |
| GWA Opp S16 | 669913 | 7434817 |
| GWA Opp S17 | 673195 | 7439118 |

| Site | Location | |
|---|---|---|
| | Easting | Northing |
| GWA Opp S18 | 691928 | 7441786 |
| GWA Opp S19 | 686882 | 7434209 |
| GWA Opp S20 | 686848 | 7434423 |
| GWA Opp S21 | 687482 | 7434412 |
| GWA Opp S22 | 677757 | 7440130 |
| GWA Opp S23 | 668089 | 7434460 |
| GWA Opp S24 | 690500 | 7441055 |
| **Targeted SRE leaf litter collection site** | | |
| Forage Site 1 | 677545 | 7440245 |
| Forage Site 2 | 688983 | 7433331 |
| Forage Site 3 | 670572 | 7438925 |
| Forage Site 4 | 663923 | 7437791 |
| Forage Site 5 | 687086 | 7434227 |
| Forage Site 6 | 689590 | 7433600 |
| Forage Site 7 | 689663 | 7441394 |
| Forage Site 8 | 693088 | 7441312 |

Datum: GDA 94
Zone: 50

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665000 670000 675000 680000 685000 690000 695000

7445000 7440000 7435000 7430000 7425000

Deposit I

Deposit B

Deposit H

GWA S1 GWA S2

GWA S9

GWA S12

Deposit C

Deposit G

GWA S11

GWA S8

GWA S7

Deposit D

GWA S10

GWA S5

GWA S6

Mt Ella

Deposit A

GWA S4

GWA S3

Deposit F

Deposit E

## Legend

- Opportunistic search
- Targeted SRE leaf litter collection site
- SM2 opportunistic recording
- Trap site
- Motion camera
- Deposit areas
- Study area

N

0 2.5 5

Kilometres

**Absolute Scale - 1:90,000**

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# Location of fauna sites

**Figure: 3.1**
**Project ID: 1458**

**Drawn: BG**
**Date: 24/9/2013**

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

Unique Map ID: BG307

**A3**

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## 3.4 POTENTIAL CONSERVATION SIGNIFICANT VERTEBRATE FAUNA

After the results of the literature review, database searches and survey results were compiled, fauna species that are listed under current legislative frameworks were identified. Three conservation lists have been developed at national (EPBC Act) and state level (WC Act and DPaW priority list).

The likelihood of a conservation significant species being present within the study area was determined by examining the following:

- fauna habitats and their condition known to exist within the study area;
- distance of previously recorded conservation significant species from the study area;
- frequency of occurrence of conservation significant species records in the region; and
- time passed since conservation significant species were recorded within, or surrounding, the study area.

Each conservation or biologically significant species potentially occurring in the study area, was assigned a likelihood of occurrence based on the below category (Table 3.4). The level of available information for each species was also taken into consideration so that species are not allocated a low likelihood of occurrence because of insufficient survey information or cryptic behaviours and ecology.

**Table 3.4 – Likelihood of occurrence categories**

| | |
|---|---|
| **RECORDED** | Species recorded during current survey |
| **HIGH** | Species recorded within, or in proximity to, the study area within 20 years; suitable habitat occurs in the study area |
| **MEDIUM** | Species recorded within, or in proximity to, the study area more than 20 years ago. Species recorded outside study area, but within 50 km; suitable habitat occurs in the study area |
| **LOW** | Species rarely, or not recorded, within 50 km, and/or suitable habitat does not occur in the study area |

## 3.5 SRE STATUS

SRE status is based on the newly released 2013 WAM SRE categories which have been developed to describe the SRE status of WA taxa using: (a) unambiguous categories; and (b) explanations of uncertainty. This has been accomplished using a two-tier classification system. In the first tier of classification, geographic distribution and taxonomic certainty are the variables used to split taxa into “Confirmed SREs”, “Widespread (not SREs)”, and “Potential SREs”. In the second tier of classification, “Potential SREs” are categorised according to the reasons they have been placed into this category and the presence of proxy-indicators for Confirmed SRE or Widespread status (Table 3.5).

**Table 3.5 – Western Australian Museum SRE categories (2013)**

| | **Taxonomic Certainty** | **Taxonomic Uncertainty** |
|---|---|---|
| Distribution < 10 000km$^2$ | **Confirmed SRE**<br>A known distribution of <10 00km$^2$.<br>The taxonomy is well known.<br>The group is well represented in collections and/ or via comprehensive sampling. | **Potential SRE**<br>Patchy sampling has resulted in incomplete knowledge of the geographic distribution of the group.<br>We have incomplete taxonomic knowledge.<br>The group is not well represented in collections.<br>This category is most applicable to situations where there are gaps in our knowledge of the taxon.<br>**Sub-categories for this SRE designation are outlined below** |
| Distribution > 10 000km$^2$ | **Widespread (not an SRE)**<br>A known distribution of >10 000km$^2$.<br>The taxonomy is well known.<br>The group is well represented in collections and/ or via comprehensive sampling. | |

**SRE SUB-CATEGORIES**

If a taxon is determined to be a "Potential SRE", the following sub-categories will further elucidate this status.

**A. Data Deficient:**

- There is insufficient data available to determine SRE status.
- Factors that fall under this category include:
    - Lack of geographic information
    - Lack of taxonomic information
    - The group may be poorly represented in collections
    - The individuals sampled (e.g. juveniles) may prevent identification to species level.

**B. Habitat Indicators:**

- It is becoming increasingly clear that habitat data can elucidate SRE status.
- Where habitat is known to be associated with SRE taxa and vice versa, it will be noted here.

**C. Morphology Indicators:**

- A suite of morphological characters are characteristic of SRE taxa.
- Where morphological characters are known to be associated with SRE taxa and vice- versa, it will be noted here.

**D. Molecular Evidence:**

- If molecular work has been done on this taxon (or a close relative), it may reveal patterns congruent or incongruent with SRE status.

**E. Research & Expertise:**

- Previous research and/or WAM expertise elucidates taxon SRE status.
- This category takes into account the expert knowledge held within the WAM taxonomy and nomenclature

All Likely, Potential and Unknown SREs should be treated as Confirmed SREs in accordance with the precautionary principle (Section 4A of the EP Act).

## 3.6 SAMPLING METHODS

The survey methods adopted by *ecologia* were aligned with relevant guidelines as identified in Section 1.2.

The survey was undertaken using a variety of sampling techniques, both systematic and opportunistic. Systematic sampling refers to data methodically collected over a fixed time period in a discrete habitat type, using an equal or standardised sampling effort. The resulting information can be analysed statistically, facilitating comparisons. Opportunistic sampling includes data collected non-systematically from both fixed sampling sites and as opportunistic records from chance encounters with fauna.

### 3.6.1 Systematic Sampling

#### 3.6.1.1 Terrestrial Mammals, Herpetofauna and Invertebrates

Trapping for terrestrial mammals, herpetofauna and invertebrates was undertaken using a standardised trapping format comprising a combination of pit-fall traps, Elliott box traps, funnel traps and cage traps.

Each trapping site consisted of the following (Figure 3.2):

- Pit-trap and drift fence: Five PVC pipe (16 x 50 cm) and five 20 L plastic buckets (30 x 40 cm) were established at each site. A 10 metre flywire drift fence (30 cm high) bisected the pits, directing fauna into the traps.
- Elliott box traps: Ten medium sized Elliott box traps (9 x 9 x 32 cm) were placed at each site, and baited with Universal Bait (a mixture of peanut butter, rolled oats and sardines). Each Elliott trap was placed between the pit trap setups. Elliott traps were shaded using Air Cell roof insulation.
- Funnel traps: Funnel traps (Ecosystematica Type III) were placed in association with drift fences. Twenty funnel traps were used per site, with a trap being placed at each end of the drift fence. Funnel traps were shaded using Air Cell roof insulation.
- Cage traps: Two Sheffield small animal traps (22 cm x 22 cm x 55 cm) were used per site with one trap placed at each end of the trap line. Traps were baited with Universal Bait.

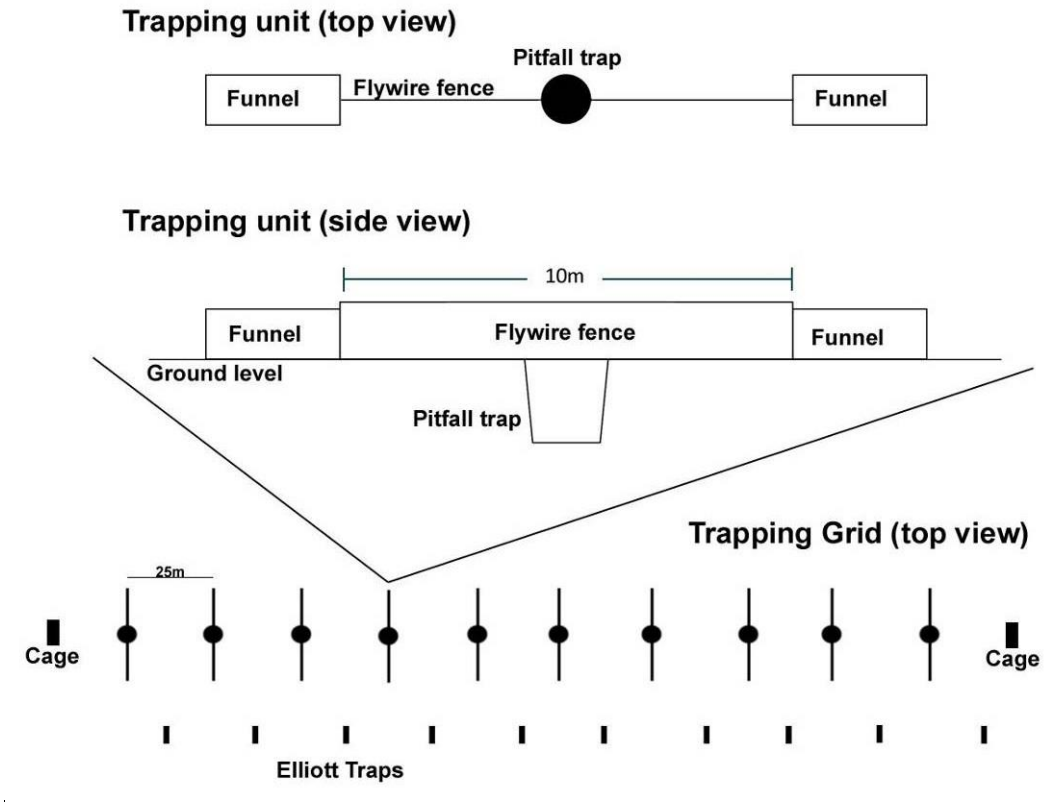


**Figure 3.2 – Diagram of the systematic sampling trap arrangement**



**Figure 3.3 – Image of single *ecologia* trap point**

### 3.6.1.2 Avifauna

Four 30 minute set-time surveys were used to document the avifauna present at each of the fauna sites for each phase of surveying. This totals two hours of systematic surveying per site per phase. During each set-time survey an ornithologist recorded the number of individuals of each species seen while actively searching similar habitat within 500 m of the survey site. This is aligned with survey methodology for the ongoing Birds Australia *Atlas of Australian Birds* project.

Survey effort was concentrated at survey sites within three hours of dawn, as this time is deemed to be the optimal times to record most bird species. Opportunistic surveys during the day and near dusk were also conducted, as they may yield species less frequently observed in the early morning, e.g. diurnal raptors.

### 3.6.1.3 Bats

Bat echolocation calls were recorded using SM2BAT+ 384 kHz ultrasonic acoustic recorders (SM2BAT). The SM2BAT has a high sampling frequency, enabling the full spectrum of the calls to be recorded without being transformed allowing greater accuracy and sensitivity. The SM2BAT was programmed to record from dusk to dawn for each night surveyed. Each systematic survey site was surveyed for one night per phase. Opportunistic sites were surveyed in areas which represented particularly good bat roosting and foraging habitat, such as rocky gorges.

### 3.6.1.4 SRE Leaf Litter Collection

At each site, three 1 $m^2$ quadrats (totalling 3 $m^2$) of leaf litter were collected and placed into a leaf-litter reducer separately (Figure 3.4). An additional eight opportunistic sites were also sampled. The contents from each collection was placed into a paper bag inside a zip-lock bag and kept separate. A small amount of wet tissue paper was placed into each sample to keep humid. Samples were then transported back to Perth in a cool, dark container where they were placed on Tullgren funnels to extract any specimens.



**Figure 3.4 – Example of the leaf litter reducer and Tullgren funnels**

#### 3.6.1.5 SRE Extraction Methods and Lab Sorting

Tullgren funnels were used to extract any animals from the collected leaf litter samples (Figure 3.4). The general principle of Tullgren funnels is that a sample of leaf litter is suspended below an incandescent lamp or heat source. Animals inhabiting the sample are forced downwards by the progressive drying of the sample and ultimately fall into the collecting vessel which is located below the sample. Samples are preserved in ethanol to allow DNA extraction if required.

After the leaf litter samples were processed on the Tullgren funnels, each sample was examined for any other animals that were not collected during Tullgren funnel extraction. Each sample was emptied into a tray and examined using a light magnifier. Any animals found were collected and immediately preserved in ethanol.

All specimens collected were examined under a Stereo microscope and sorted into related groups. These specimens were labelled with the Project name, site number and coordinates, the trap number or leaf-litter sift number and the collectors, and were sent to the relevant taxonomic experts for further identification. Table 3.6 shows the list of taxonomic specialists used for identification and relevant experience.

**Table 3.6 – Taxonomic specialists used for invertebrate identification**

| External Consultant | Institution | Relevant Experience |
|---|---|---|
| Dr Mark Harvey | Western Australian Museum | Taxonomic specialist in arachnids and millipedes |
| Dr Amber Beavis | Western Australian Museum | Taxonomic specialist in pseudoscorpions |
| Corey Whisson | Western Australian Museum | Taxonomic specialist in molluscs |
| Dr Bill Humphreys | Western Australian Museum | Taxonomic specialist in subterranean fauna |
| Dr Erich Volschenk | Private consultant | Taxonomic specialist in scorpions |
| Dr Simon Judd | Private consultant | Taxonomic specialist in isopods |
| Dr Volker Framenau | Private consultant | Taxonomic specialist in spiders |

### 3.6.2 Opportunistic Data

#### 3.6.2.1 Nocturnal Searching

The study area was searched at night using a combination of road transects and opportunistic ground searches using head torches and hand held spotlights to uncover nocturnal species, including geckos, snakes, frogs, birds and invertebrates.

Each systematic trapping site was surveyed by spotlight for at least 60 minutes for each phase. Sites GWA S1, 2 and 9 did not have nocturnal surveys completed due the long travel times required to reach these sites and the associated health and safety implications.

#### 3.6.2.2 Diurnal Searching

Both trapping and opportunistic sites were searched by hand for both vertebrate and invertebrate cryptic species, which comprised searching beneath the bark of dead trees, breaking open old logs, stumps and dead free-standing trees, investigating burrows and over-turning logs and stones. Sites were selected on the basis of fauna habitat (targeting uncommon habitats or habitats poorly represented by trapping sites) and the possibility of their harbouring conservation significant fauna.

Fauna were also recorded while searching, travelling and during trap establishment within the study area during the day and night. Tracks, diggings, scats, burrows and nests were recorded where possible.

A total of 24 opportunistic survey sites were established during this survey, totalling 47.2 hours of diurnal searching.

#### 3.6.2.3 Motion Camera Trapping

Motion sensor cameras were used in areas with a high likelihood of animal activity such as water sources to detect fauna species. The Bushnell Trophy Cam, model number 119415 was used. The camera is triggered by movement by a highly sensitive Passive Infra-Red motion sensor and functions day and night taking either video footage or photos (Bushnell Outdoor Products 2009).

A total of five motion cameras were set up at five sites for a total of 576 hours.

#### 3.6.2.4 Invertebrate foraging

Opportunistic foraging involved physically searching through microhabitats for SREs. The underside of rocks and logs were closely investigated for SRE invertebrates. Snail shells were collected and trapdoor spiders excavated from their burrows, with their location and date of collection documented.

### 3.7 SURVEY EFFORT

Survey effort expended within the study area is shown in Table 3.7 and is summarised in the following sections.

#### 3.7.1 Vertebrate Fauna

- 12 trapping sites were open for 14 nights, totalling 7,056 trapnights;
- 53.8 hours spent surveying for birds;
- 51.6 hours spent conducting diurnal searches;
- 25 hours spent conducting nocturnal searches;
- 576 hours of motion camera trapping; and
- 340 hours of bat call recordings analysis.

#### 3.7.2 Conservation Significant Terrestrial Vertebrate Fauna

Excluding systematic trapping effort, targeted potential conservation significant vertebrate fauna were searched for opportunistically using the following methods:

- approximately 28 hours of opportunistic searches and 461 camera trap hours for evidence of Northern Quolls and Pilbara Olive Python;
- a total of 340 hours of bat call recordings were analysed for Ghost Bat and Pilbara Leaf-nosed Bat;
- approximately 12 hours of diurnal searches for Western Pebble-mound Mouse mounds;
- approximately six hours of bird surveys for Rainbow Bee-eater;
- five hours of spotlighting for the Pilbara Barking Gecko; and
- four hours of nocturnal call playback was performed for Bush Stone-curlew.

Other potential conservation significant species were not targeted specifically during searches due to their ability to occur within a variety of habitats (Peregrine Falcon, Grey Falcon, Australian Bustard) and difficulty in detection (*Ramphotyphlops ganei*), however all zoologists conducting the assessment were training in the identification and recognition of these species.

### 3.7.3 SRE Invertebrates

- Twelve sites consisting of dry pitfall and funnel traps were open for 14 nights, totalling 5,040 trapnights;
- 51.6 hours were spent actively foraging (looking through leaf litter, under bark and stones etc); and
- A total of 60 leaf litter collections (1m$^2$ quadrat) were taken from 18 locations.

**Table 3.7 – Survey effort**

| Site | Pit Traps (trap nights) | | Funnels (trap nights) | | Elliotts (trap nights) | | Cages (trap nights) | | Bird Survey (min) | | Leaf litter collection ($1m^2$quadrat) | Diurnal Opp Search (min) | | Bat Recording (hour) | | Nocturnal Search (min) | | Camera Trapping (hour) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ph1 | Ph2 | Ph1 | Ph2 | Ph1 | Ph2 | Ph1 | Ph2 | Ph1 | Ph2 | | Ph1 | Ph2 | Ph1 | Ph2 | Ph1 | Ph2 | Ph1 | Ph2 |
| GWA S1 | 70 | 70 | 140 | 140 | 70 | 70 | 14 | 14 | 120 | 120 | 3 | 60 | - | 12 | 12 | - | - | - | - |
| GWA S2 | 70 | 70 | 140 | 140 | 70 | 70 | 14 | 14 | 120 | 120 | 3 | - | - | 12 | 12 | - | - | - | - |
| GWA S3 | 70 | 70 | 140 | 140 | 70 | 70 | 14 | 14 | 120 | 120 | 3 | 60 | - | 12 | 12 | 80 | 60 | - | - |
| GWA S4 | 70 | 70 | 140 | 140 | 70 | 70 | 14 | 14 | 120 | 120 | 3 | 60 | - | 12 | 12 | 80 | 60 | - | - |
| GWA S5 | 70 | 70 | 140 | 140 | 70 | 70 | 14 | 14 | 120 | 120 | 3 | 60 | - | 12 | 12 | 80 | 60 | - | - |
| GWA S6 | 70 | 70 | 140 | 140 | 70 | 70 | 14 | 14 | 120 | 120 | 3 | - | 30 | 12 | 12 | 60 | 60 | - | - |
| GWA S7 | 70 | 70 | 140 | 140 | 70 | 70 | 14 | 14 | 120 | 120 | 3 | 120 | 30 | 12 | 12 | 60 | - | - | - |
| GWA S8 | 70 | 70 | 140 | 140 | 70 | 70 | 14 | 14 | 120 | 120 | 3 | - | 20 | 12 | 12 | 60 | 60 | - | - |
| GWA S9 | 70 | 70 | 140 | 140 | 70 | 70 | 14 | 14 | 120 | 120 | 3 | 60 | - | 12 | 12 | - | - | - | - |
| GWA S10 | 70 | 70 | 140 | 140 | 70 | 70 | 14 | 14 | 120 | 120 | 3 | - | 30 | 4 | 12 | 60 | 60 | - | - |
| GWA S11 | 70 | 70 | 140 | 140 | 70 | 70 | 14 | 14 | 120 | 120 | 3 | - | 60 | 12 | 12 | 80 | 60 | - | - |
| GWA S12 | 70 | 70 | 140 | 140 | 70 | 70 | 14 | 14 | 120 | 120 | 3 | - | - | 12 | 12 | 60 | 120 | - | - |
| Opportunistic | - | - | - | - | - | - | - | - | 320 | 30 | 24 | 1240 | 1270 | 24 | 36 | 340 | - | 432 | 144 |
| **Phase Total** | **840** | **840** | **1680** | **1680** | **840** | **840** | **168** | **168** | **1760** | **1470** | **60** | **1660** | **1440** | **160** | **180** | **960** | **540** | **432** | **144** |
| **Total** | **1,680** | | **3,360** | | **1,680** | | **336** | | **3,230** | | **60** | **3,100** | | **340** | | **1,500** | | **576** | |

## 3.8 FAUNA BROAD-SCALE HABITAT MAPPING

A fauna habitat type broadly describes an area of habitat that is distinguishable in its vegetation and land features from its surroundings, and that is likely to support fauna assemblages which are different to those in other fauna habitats. Fauna habitat types were identified, described and mapped taking in to consideration the following existing information:

- Vegetation associations (Beard 1981; Shepherd et al. 2002);
- IBRA subregions;
- Aerial photography; and
- On ground observations.

To aid in determining the fauna habitat type and its characteristics, the following on ground parameters were taken into consideration:

- Vegetation type and structure;
- Soil characteristics (soil structure and substrate);
- Landscape and landform features; and
- Composition of terrestrial fauna species.

## 3.9 DATA ANALYSIS

### 3.9.1 Survey Adequacy

There are three general methods of estimating species richness from sample data: extrapolating species-accumulation curves (SACs), fitting parametric models of relative abundance, and using non-parametric estimators (Bunge and Fitzpatrick 1993; Colwell and Coddington 1994; Gaston 1996). In this report, the level of survey adequacy was estimated using SACs, which graphically illustrate the accumulation of new species as more individuals are recorded. Ultimately, the asymptote is reached at the level at which no new species are present. To eliminate features caused by random or periodic temporal variation, the sample order was randomised 1,000 times using EstimateS (version 8, Colwell 2009). In order to estimate the theoretical maximum for each fauna group, a Michaelis-Menten enzyme kinetic curve was calculated and used as a stopping rule technique.

Only the results of systematic surveys were included in SAC analysis, as this form of analysis assumes a standard sampling effort. Therefore, species recorded through opportunistic methods are not included. Separate analyses were carried out for each species group (mammal, reptile, bird, invertebrates).

### 3.9.2 Habitat Assessment

Habitat types have been established in the literature as playing an important role in SRE invertebrate and vertebrate fauna diversity. Variability of habitats has been strongly linked with invertebrate and vertebrate species richness and composition. The expectation of this study was to find a relationship between species richness and habitat type, with higher species richness in moister habitats and less in drier habitats.

Statistical analyses were carried out on the complete data set from the 12 sites sampled during the survey. The primary aim of the statistical analysis was to determine whether the vertebrate and invertebrate assemblages (containing SRE invertebrate groups) recorded from the study area differ in terms of richness (number of taxa present) and structure (relative abundance of taxa).

Differences between habitat types and species richness were tested with a one-way ANOVA. Prior to running the ANOVA, a test of normality (Anderson –Darling) and Homogeneity (Barlett's and Levene) was performed in order test if the data set complies with the ANOVA assumptions.

To analyse differences in species diversity between habitats, a Bray Curtis similarity index was calculated for each pairwise site comparison followed by a non-metric multidimensional scaling (MDS) of similarity matrix. Stress values below 0.20 were considered to indicate a good fit of the scaling to the matrix. The dimensions that reduced the majority of the "raw stress" were chosen for the final scaling. In addition, to test whether the differences in species diversity between habitat types were significant, analyses of similarity (ANOSIM) (Clarke 1993) comparisons were made using the one-way ANOSIM function in the PAST software package (Hammer *et al.* 2001). ANOSIM was calculated using the Bray-Curtis Similarity Index with 999 permutations. Bray Curtis is a widely used and well-tested index for incidence data. The analysis was run without the inclusion of rare species, to avoid potential bias. "Rare" species were defined as those species found in only one sample, based on visual inspection of a histogram of species abundances.

Analysis of the fauna survey data was undertaken to determine the similarities in fauna communities and identify any unique fauna habitats. Separate analyses were carried out for terrestrial fauna (mammal and reptile) and avifauna.

## 3.10 TAXONOMY AND NOMENCLATURE

Nomenclature for mammals, reptiles and amphibians within this report is as per *Western Australian Museum Checklist of the Vertebrates of Western Australia*, birds according to Christidis and Boles (2008). References used for fauna identification are listed in Table 3.8.

All invertebrate specimens collected during the SRE trapping have been lodged with the WA Museum and identified by external experts (Table 3.6).

**Table 3.8 – References used for identification**

| Fauna Group | Reference |
|---|---|
| Mammals | Menkhorst and Knight (2011), Van Dyck and Strahan (2008) |
| Bats | Churchill (1998), Menkhorst and Knight (2011) |
| Birds | Simpson and Day (2004) |
| Reptiles | Cogger (2000), Wilson and Swan (2010) |
| Geckos | Storr *et al*. (1990), Wilson and Swan (2010) |
| Skinks | Storr *et al*. (1999), Wilson and Swan (2010) |
| Dragons | Storr *et al*. (1983), Wilson and Swan (2010) |
| Varanids | Storr *et al*. (1983), Wilson and Swan (2010) |
| Legless Lizards | Storr *et al*. (1990), Wilson and Swan (2010) |
| Snakes | Storr *et al*. (2002), Wilson and Swan (2010) |
| Amphibians | Tyler and Doughty (2009), Cogger (2000) |

## 3.11 ANIMAL ETHICS

Surveying was conducted as per *ecologia*'s Animal Ethics Code of Practice, which conforms to Section 5 of the *Australian code of practice for the care and use of animals for scientific purposes* (NHMRC 2004).

In most cases, fauna were identified in the field and released at the point of capture. Where the taxonomy of specimens was not clearly discernible, or when species were collected that are known to exhibit significant morphological variation or are not yet fully described, vouchers specimens were lodged with the W.A. Museum (Appendix D). Voucher specimens were maintained according to WA Museum guidelines to ensure minimum stress to captured animals.

## 3.12 SURVEY TEAM AND LICENCES

Field survey team members are listed in Table 3.9. The survey was conducted under DEC Regulation 17 Licence SF008716.

**Table 3.9 – Field survey personnel**

| Survey Member | Expertise | Qualification | Experience |
|---|---|---|---|
| **Phase 1** | | | |
| Astrid Heidrich | Herpetology | M.Sc. | 7 years |
| Sean White | Invertebrate Zoology | B.Sc. | 7 years |
| Nigel Jackett | Ornithology | B.Sc. (Hons) | 7 years |
| Bruce Greatwich | Ornithology | B.Sc. | 5 years |
| Leigh Smith | Herpetology | - | 5 years |
| Farhan Bokhari | Invertebrate Zoology | B.Sc. (Hons) | 5 years |
| Anna Nowicki | Zoology | B.Sc. (Hons) | 3 years |
| Jesse Forbes-Harper | Zoology | B.A B.Sc. (Hons) | 3 years |
| **Phase 2** | | | |
| Sean White | Invertebrate Zoology | B.Sc. | 7 years |
| Mei Chen Leng | Invertebrate Zoology | B.Sc. (Hons) | 7 years |
| Mariana de Campos | Botany | Ph.D. | 7 years |
| Bruce Greatwich | Ornithology | B.Sc. | 5 years |
| Anna Nowicki | Zoology | B.Sc. (Hons) | 3 years |
| Jesse Forbes-Harper | Zoology | B.A B.Sc. (Hons) | 3 years |
| **External consultant** | | | |
| Bob Bullen | Bat call analysis | - | 15 years |

# 4 RESULTS

## 4.1 BROAD-SCALE HABITATS

A total of nine broad-scale habitat types have been assessed as existing within the study area; 'footslope or plain', 'hilltop, hillslope, ridge or cliff', 'mixed Acacia woodland', 'mesa top', 'cracking clay', 'major gorge and gully', 'major drainage', 'mulga woodland' and 'cleared area'. Table 4.1 displays the area each habitat type occupied at the time of surveying, and the percentage of this occupancy compared to the other habitat types, within the study area. The fauna habitats are mapped in Figure 4.1 and described in greater detail in section 4.1.2 to 4.1.10. No habitats were recorded that are regarded as rare or unique to the study area.

**Table 4.1 – Summary of fauna habitat type areas**

| Fauna Habitat | Area inside study area ($km^2$) | Percentage of total study area (%) |
|---|---|---|
| Footslope or plain | 80.37 | 45.76 |
| Hilltop, hillslope, ridge or cliff | 51.95 | 29.58 |
| Mixed Acacia woodland | 26.15 | 14.89 |
| Mesa top | 11 | 6.26 |
| Cracking clay | 2.42 | 1.38 |
| Major gorge and gully | 1.70 | 0.97 |
| Major drainage | 0.51 | 0.29 |
| Mulga woodland | 0.49 | 0.28 |
| Cleared area | 1.06 | 0.60 |
| **Total** | **175.65** | **100** |

### 4.1.1 Broad-scale habitat survey effort

When survey effort in Table 3.7 is assessed against the corresponding habitats present, survey effort per habitat type can be seen. These results are shown in Table 4.2.

**Table 4.2 – Survey effort per habitat type**

| Survey effort | Habitat Type | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Footslope or plain** | **Hilltop, hillslope, ridge or cliff** | **Mixed Acacia woodland** | **Mesa top** | **Cracking clay** | **Major gorge and gully** | **Major drainage system** | **Mulga woodland** | **Cleared area** |
| Systematic trap sites | GWA S4, S5, S7, S9, S11 | GWA S6 | GWA S10 | GWA S1, S2 | GWA S8 | GWA S12 | - | GWA S3 | - |
| Pit traps (nights) | 350 | 70 | 70 | 140 | 70 | 70 | - | 70 | - |
| Funnels (nights) | 700 | 140 | 140 | 280 | 140 | 140 | - | 140 | - |
| Elliotts (nights) | 350 | 70 | 70 | 140 | 70 | 70 | - | 70 | - |
| Cages (nights) | 70 | 14 | 14 | 28 | 14 | 14 | - | 14 | - |
| Bird surveys (min) | 1,200 | 240 | 240 | 480 | 240 | 240 | 350 | 240 | - |
| Leaf litter collection ($1m^2$ quadrat) | 27 | 6 | 3 | 9 | 3 | 6 | - | 3 | - |
| Diurnal Opp Search (min) | 360 | 380 | 180 | 100 | 20 | 1,540 | 280 | 240 | - |
| Bat Recording (hour) | 112 | 48 | 24 | 48 | 24 | 60 | - | 24 | - |
| Nocturnal Search (min) | 460 | 120 | 140 | - | 120 | 180 | - | 140 | - |
| Camera Trapping (hour) | 115 | - | - | - | - | 461 | - | - | - |

660000 665000 670000 675000 680000 685000 690000 695000

7445000 7440000 7435000 7430000 7425000

## Legend

- Study area
- Mixed Acacia woodland
- Major drainage
- Footslope or plain
- Cracking clay
- Mesa top
- Mulga woodland
- Hilltop, hillslope, ridge or cliff
- Major gorge or gully
- Cleared area

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Kilometres

**Absolute Scale - 1:102,000**

ecologia ENVIRONMENT

# Fauna habitats

**Figure: 4.1**
**Project ID: 1458**

**Drawn: BG**
**Date: 15/4/2013**

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

Unique Map ID: BG301

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### 4.1.2 Footslope or plain

Footslope or plain was the most abundant habitat type and occupied 45.76% of the study area (Table 4.1). The vegetation cover on this habitat is typically comprised of *Eucalyptus leucophloia, E. gamophylla, Corymbia hamersleyana, A. pruinocarpa, A inaequilatera* and species in the *A. aneura* complex open woodland to sparse trees over *Acacia* spp*., Eremophila* spp., *Ptilotus* spp., *Senna* spp. and *Solanum lasiophyllum* open shrubland over *Triodia* spp. open hummock grassland Figure 4.2.

Due to the large area that this habitat type covers, a wider range of plant taxa are associated with it, particularly in the shrub and grass strata. The most abundant shrubs observed were *Acacia bivenosa, A. colei, A. acradenia, A. tetragonophylla, Eremophila fraseri, E. forrestii, E. caespitosa, E. latrobei, Ptilotus calostachyus, P. nobilis* subsp. *nobilis, Senna artemisioides* (various subspecies and varieties) and *Senna glutinosa* (various subspecies and varieties). The hummock grasses present in this vegetation type were *Triodia wiseana, T. basedowii, T. longifolia* and *T. pungens*. The footslope or plain habitat type included minor drainage lines, where *T. longifolia, Gossypium robinsonii and Acacia ancistrocarpa* were characteristic.

This habitat type was associated mostly with orange sandy-clay soils on flat ground. The soil was recorded as loose, a crust or rocky, with few to common ironstone rock, gravel and pebble cover. Common disturbances observed in this habitat type include introduced flora species and animal tracks.



**Figure 4.2 – Footslope or plain habitat type**

### 4.1.3 Hilltop, hillslope, ridge or cliff

The hilltop, hillslope, ridge or cliff habitat type was recorded from 29.58% of the surveyed area and was therefore the second most common habitat within the study area (Table 4.1). The vegetation of this fauna habitat typically includes *Eucalyptus leucophloia* and mulga (*Acacia aneura* complex) isolated trees over sparse shrubland of a combination or selection of *Senna artemisioides* subsp. *artemisioides, S. artemisioides* subsp. *filifolia, Ptilotus rotundifolius, Tribulus suberosus, Eremophila fraseri* and *Acacia ancistrocarpa* sparse shrubland to isolated shrubs over *Triodia pungens* hummock grassland (Figure 4.3). In general this habitat type has a predominantly open character with very little vegetation cover.

In some areas, there was also the presence of *Acacia pruinocarpa, A. maitlandii, Acacia synchronicia,* different varieties and subspecies of *Senna artenisioides* and *Senna glutinosa*, as well as sparse herbs. Variations in the lower stratum include the presence of *Triodia wiseana, Eriachne* spp. and *Cymbopogon obtectus.*

Some variation was observed in the landforms, soil composition and rock abundance in this habitat type. The most commonly observed characteristics were soils of sandy-clay texture, ranging from

orange to brown in colour and with abundant ironstone rocks, boulders and/or surface plates. The slope ranged from minor to very steep, with smaller vegetation cover in the steeper areas.



**Figure 4.3 – Hilltop, hillslope, ridge or cliff habitat type**

### 4.1.4 Mixed *Acacia* woodland

This habitat type occupied 14.89% of the study area (Table 4.1). Vegetation included open to medium dense woodland with a tree stratum of mulga (*Acacia aneura* complex) and scattered *Acacia pruinocarpa*, over *Acacia maitlandii* and *Ptilotus* sp. sparse shrubland, over *Triodia wiseana* and *T. pungens* open hummock grassland dominated the mixed *Acacia* woodland habitat type (Figure 4.4).

Many other *Acacia* species were present in this habitat type, including *A. bivenosa, A. ayersiana, A. pyrifolia, A. sibirica;* as well as *Senna* shrubs (mainly varieties and subspecies of *S. artemisioides* and *S. glutinosa*).

The soils consisted of loam clay with continuous layers of small ironstone pebbles on the surface. The habitat was mostly flat with no or very small drainage channels.

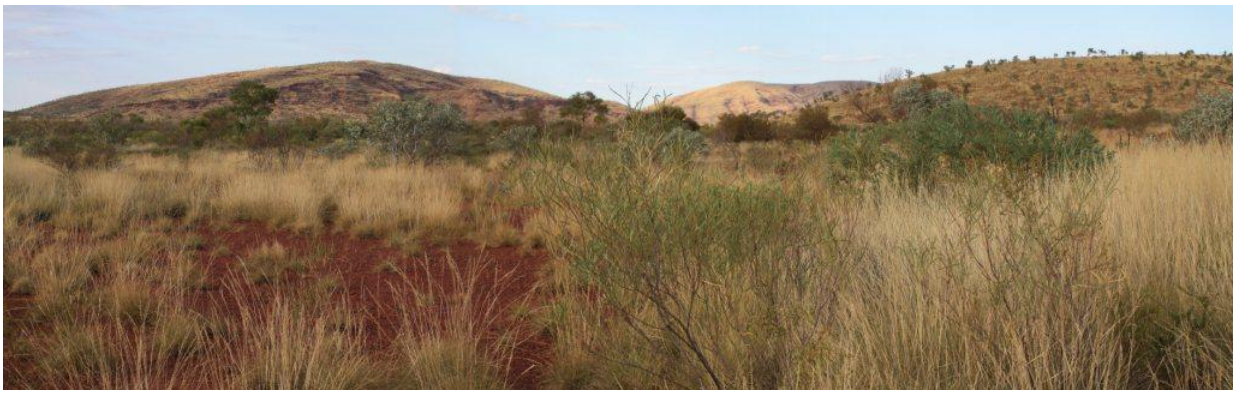


**Figure 4.4 – Mixed Acacia woodland habitat type**

### 4.1.5 Mesa top

The mesa top habitat type is located in the north-east corner of the study area, in Deposit H. Although similar to the hilltop, hillslope, ridge or cliff habitat type, it differs in that it is an elevated plateau, and supports dense vegetation in patches (Figure 4.5). The mesa top habitat type occupied 6.26% of the study area at the time of surveying (Table 4.1).

Mesa tops within the study area held an *Eucalyptus leucophloia, E. gamophylla, Acacia pruinocarpa* and mulga (*A. aneura* complex) open woodland to sparse trees, over *A. maitlandii, A. hamersleyensis, Keraudrenia velutina* and *Senna glutinosa* subsp. *glutinosa* open shrubland, over *Triodia pungens, T. longifolia* and/or *T. wiseana* open hummock grassland.

This habitat type included minor drainage lines, where *Gossypium robinsonii* was also present, as well as sparsely vegetated rocky outcrops. The geology of this habitat type is also notably different. Figure 2.5 shows the geology of the mesa top habitat type as unit A3b, which is described as sedimentary rocks. This geology differs from the mafic volcanic and dolerite and gabbros geology of the remaining area of the study area (Table 2.3).



**Figure 4.5 – Mesa top habitat type**

### 4.1.6 Cracking clay

The cracking clay habitat type was recorded from one location within the study area and occupied 1.38% of the total study area (Table 4.1). The cracking clay habitat type supported very few trees and tall shrubs and is characterised by open and sparse low vegetation with approximately half of its area being bare ground (Figure 4.6).

Isolated shrubs of *Salsola australis, Boerhavia paludosa* and *Ptilotus nobilis* subsp. *nobilis* were present over open tussock grassland of *Aristida* sp., *Brachyachne* sp. and *Astrebla pectinata.* The soil was recorded as dark orange sand-clay to clay with an undulating surface caused by crabholes and gilgai. Rocks and pebbles were very rare and when present, the rock type was consistently ironstone.

Although no signs of fire were evident, parts of the vegetation on the cracking clay habitat type were desiccated, leaving some areas completely bare.



**Figure 4.6 – Cracking clay habitat type**

### 4.1.7 Major gorge and gully

The major gorge and gully habitat type was recorded from sections within the hilltop, hillslope, ridge or cliff habitat type and occupies 0.97% of the study area (Table 4.1). The vegetation recorded commonly included *Acacia aptaneura* open woodland over *Ptilotus obovatus* isolated shrubs over *Themeda triandra* and *Eriachne* sp. open tussock grassland and *Triodia pungens* isolated hummock grasses.

*Astrotricha hamptonii, Ficus brachyopoda* and *Cyperus cunninghamii* were species found only in the major gorge and gully habitat, and are considered descriptive of this habitat type, although not dominant.

Major gorge and gully were frequently very steep and with an irregular surface, formed by surface plates and boulders of ironstone and with little exposed soil. The soil, when available, was described as orange-brown and sandy to sandy-clay (Figure 4.7).



**Figure 4.7 – Major gorge or gully habitat type**

### 4.1.8 Major drainage

The major drainage habitat type occupies only 0.29% of the study area (Table 4.1). The major drainage systems were characterised by open woodland of *Eucalypts victrix, Acacia citrinoviridis* and *Acacia aptaneura*, over *Senna artemisioides* subsp. *oligophylla*, *Rhagodia eremaea*, *Ptilotus obovatus*, *Tephrosia rosea* and Malvaceae spp. shrubland over *Themeda triandra* and *Bothriochloa* sp. sparse tussock grasses and/or *Triodia pungens* sparse hummock grasses (Figure 4.8).

Some variation in the vegetation composition was observed between the different major drainage systems, with varying prevalence of the taxa above mentioned, and in some cases, increased dominance of other species, such as *Pterocaulon sphacelatum, Gossypium robinsonii* or *Evolvulus alsinoides* var. *villisocalyx*.

This habitat occurred mostly on soils of sandy-clay texture that ranged from orange - red to brown in colour and with few to many rocks, pebbles and gravel. The soils were well drained and the rock type present in the major drainage systems was ironstone.



**Figure 4.8 – Major drainage habitat type**

### 4.1.9 Mulga woodland

Mulga woodland was recorded from one location and occupied 0.28% of the study area. The mulga woodland habitat type consists of both groved and banded mulga, where different species of the *Acacia aneura* complex were present in a closed woodland, over *Ptilotus obovatus* and juvenile mulga trees sparse shrubland, over *Maireana* sp. and *Salsola australis* isolated herbs and *Aristida* sp. and *Cymbopogon obtectus* isolated tussock grasses (Figure 4.9) creating distinct micro-habitats that include dense leaf litter and shaded zones.

The mulga complex was formed by a group of closely related species, formerly different varieties of *Acacia aneura* and currently split into different species. The most common species in the "mulga woodland" habitat type was *Acacia aptaneura* and *A. pteraneura*.

The soils of this habitat type were orange to red and sandy-clay with no rocks. The slope was negligible and this area of habitat was very consistent and with little variation.



**Figure 4.9 – Mulga woodland habitat type**

### 4.1.10 Cleared area

Some areas within the study area were cleared for infrastructure such as major roads (e.g. Borefields road) and airstrips. These areas are unique as they support very little vegetation, and have therefore been separated from the remaining habitat types. A total of 0.60% of the study area was recorded as being cleared.

### 4.1.11 Fauna habitat analysis

Common habitat types were sampled by a larger number of systematic trapping sites than less common habitat types. Six of the nine fauna habitats within the study area were sampled with systematic trapping sites during the Level 2 fauna assessment. Five trapping sites (GWA S4, S7, S8 S9 and S11) were installed in the dominant habitat type, footslope or plain. Two trap sites were installed within the Mesa top with dense shrubs habitat type (GWA S1 and S2). One trap site was installed within the Mulga woodland (GWA S3), Hilltop, hillslope, ridge or cliff (GWA S6), mixed Acacia woodland (GWA S10) and cracking clay (GWA S12).

No trapping sites were installed within the gorge and gully, cleared area or major drainage line habitat types. However, these habitat types were targeted with greater opportunistic survey effort to ensure adequate sampling of each habitat type across the study area.

A one-way ANOSIM test and MDS plot of the trapping sites within the different habitat types was completed for data collected systematically for both avifauna and trapped terrestrial fauna. The results from the one-way ANOSIM test suggest a difference between the habitats. Trapped terrestrial fauna results for the R value was 0.1473 (R value ranges from -1 to 1, with 1 indicating that the groups are dissimilar and -1 indicating that the groups are similar) and a p-value of 0.0027 (p-value of <0.05 indicating a significant difference). From Avifauna results,the R value was 0.3133 and a p-value of 0.0001. Both the results from the one-way ANOSIM test for systematically collected data suggest a difference between habitat types.

The results of the MDS plot visually do not display a clear difference in habitat types (Figure 4.10). The avifauna MDS plot shows a slight difference in birds recorded between mesa top with dense shrubs, cracking clay, hilltop, hillslope, ridge or cliff and mixed acacia woodland habitat types. The mulga woodland habitat, based on avifauna assemblage, visually appears to be the most distinct. The differences observed in the analysis of the above habitats, may be a result of reduced survey effort with one or two sites located in these habitats only. It is observed the dominate habitat type, footslope or plain overlaps the majority of all other habitats sampled. This is likely due to the increased survey effort (five systematic trap sites) in this habitat, resulting in the detection of more bird species.

As with the avifauna MDS plot, the trappable fauna MDS plot does not provide a clear difference in habitat types (Figure 4.10). The mulga woodland habitat type shows a tight cluster of similar species records, which is consistent with the avifauna results suggesting that this habitat type is most disjunct in its fauna assemblage, when compared to the other habitats. All other habitats appear to have significant overlap and similarity in the fauna assemblages recorded. This is likely due to a number of habitat generalist species which were recorded regularly. An example of this is the recording of the Sandy Inland Mouse (*Pseudomys hermmanbergensis*) and skink *Ctenotus pantherinus* at 12 of the 12 and 10 of the 12 systematic trapping sites respectively (Appendix F).

Overall, the results from the statistical habitat assessment suggest little difference in fauna assemblages between the different habitat types within the study area. These results are likely to be influenced by the presence of a number of habitat generalists recorded at many sites and in many habitats.

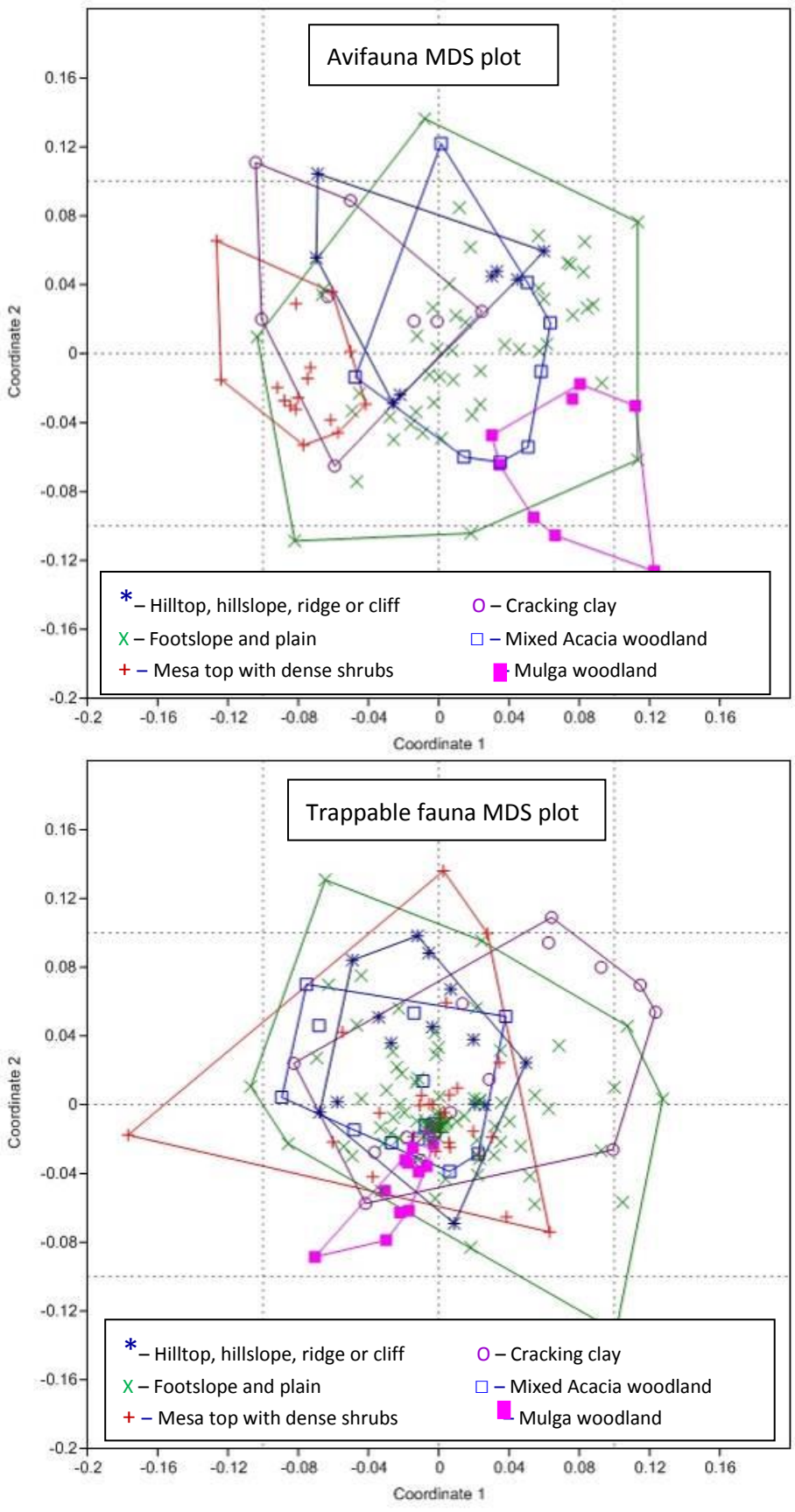



**Figure 4.10 – Fauna habitat MDS plot analysis**

## 4.2 VERTEBRATE FAUNA ASSEMBLAGE

A total of 23 species of native mammals, two species of introduced mammal, 80 species of bird and 64 species of reptile were recorded during this survey. No species of amphibian were recorded. Of the species recorded, six species were of conservation significance. The site by species matrix of species recorded during the Level 2 vertebrate fauna assessment is presented in Appendix F.

### 4.2.1 Mammals

A total of 23 native and two introduced mammals were recorded during this survey. This includes five dasyurids (small, carnivorous marsupials), three macropods (kangaroos), nine species of bat, five murids (mice), one species of canine (the dingo) and two species of introduced mammals (House Mouse and Rabbit) (Appendix F). The majority of species were recorded during both phases of surveying with the exception of the Delicate Mouse (*Pseudomys delicatulus*) which was only recorded during Phase 1 of surveying (Appendix F). Murids and dasyurids were captured in pitfall and Elliott traps at systematic trapping sites. Macropods were observed during diurnal and nocturnal opportunistic searches and nocturnal road spotting. Bats were identified from calls recorded on SM2BAT recorders.

There were a relatively large number of individuals of some murids and some dasyurid species recorded. The most frequently trapped species being the Sandy Inland Mouse (*Pseudomys hermannsburgensis*) with 73 records, the Common Rock-rat (*Zyzomys argurus*) with 52 records, the Pilbara Ningaui (*Ningaui timealeyi*) and the Stripe-faced Dunnart (*Sminthopsis macroura*) with 35 records each. Other abundant mammal species included Little Red Kaluta (*Dasykaluta rosamondae*; 34 records) and Desert Mouse (*Pseudomys desertor*; 29 records).

### 4.2.2 Birds

In total, 80 species of bird were recorded from the study area. The family Meliphagidae was the most diverse group recorded during this survey, comprising nine species of honeyeaters. The second most diverse group was the family Accipitridae which comprised seven species of birds of prey.

A large number of bird species were recorded during this survey when compared to other surveys conducted in the region (Appendix E). Several species were recorded in high numbers and from many of the sites, and can be considered to represent the common bird species of the study area; Budgerigar (1,010 records), Zebra Finch (840 records), Fork-tailed Swift (553 records), Weebill (411 records), Singing Honeyeater (288 records), Black-faced Woodswallow (182 records) and Yellow-throated Miner (152 records). Several of these species, such as Budgerigar, Black-faced Woodswallow and Fork-tailed Swift, are nomadic and appear in areas after high rainfall when food resources are high, or in the case of the Fork-tailed Swift are associated with thunderstorms.

### 4.2.3 Herpetofauna

In total, 64 species of reptiles were recorded during this survey. This included 21 skinks, 13 geckos (eight diplodactylid species, four gekkonid species and two carphodactylid species), 11 elapids (venomous snakes), six pygopods (legless lizards), five dragon species, six varanid (monitor lizard) species and one python. The activity of reptiles during the survey was moderate to high and resulted in good diversity of species recorded (Appendix E).

The most common species trapped were *Ctenophorus caudicinctus* (121 records*), Ctenotus pantherinus* (114 records), *Heteronotia binoei* (72 records), *Ctenotus helenae* (68 records), *Gehyra variegata and Ctenotus saxatilis* (61 records each), and *Carlia munda* (48 records), all of which are common species throughout the Pilbara region.

As typical for hot weather conditions, the activity of reptiles was recorded to be high and there was also a relatively large number of elapids recorded (11 species). Noteworthy is the record of the Pilbara Bandy Bandy (*Vermicella snelli*) which is rarely caught or observed due to its secretive nature.

No amphibian species were recorded.



**Figure 4.11 – Photo of captured Pilbara Bandy Bandy**

### 4.2.4 Vertebrate endemic species and species of biological significance

Species endemic to the Pilbara, recorded during the survey include: the Pilbara Ningaui (*Ningaui timealeyi*), Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia* (Pilbara form)), Banded Knob-tailed Gecko (*Nephrurus wheeleri cinctus*), *Underwoodisaurus seorsus*, *Delma pax, Ctenotus rubicundus, C. rutilans*, Pilbara Rock Monitor (*Varanus pilbarensis*), *V. bushi* and Rufous Whipsnake (*Demansia rufescens*).

One individual of the small skink, *Ctenotus rutilans* was vouchered during phase 1 as field identification of morphology was not consistent with information in identification guides (Storr *et al.* 1999; Cogger 2000). Subsequent genetic analysis by the WAM confirmed the specimen as *Ctenotus rutilans*, despite a number of morphological characteristics not being typical of this species. Further taxonomic work is being carried out on this species complex to resolve current identification uncertainties (pers. comm. P. Doughty).



**Figure 4.12 – Photo of vouchered *Ctenotus rutilans* indvidual from survey**

A total of four individuals of the skink *Ctenotus robustus* (Figure 4.13) were recorded from site GWA S8 during phase 2 only (Appendix F). Based on previous records shown on NatureMap, these records represent an approximately 120 km range extension to the south for this species (DPaW 2013).



**Figure 4.13 – Photo of *Ctenotus robustus* recorded from survey**

## 4.3 POTENTIAL CONSERVATION SIGNIFICANT VERTEBRATE FAUNA

The literature review revealed a potential 21 vertebrate fauna species of conservation significance; six mammal species, 12 bird species and three reptile species (Appendix E). An assessment of their likelihood of occurrence was completed, based on the categories outlined in section 3.4, with the results summarised in Table 4.3. Regional records of conservation significant vertebrate fauna where point locations exist, have been mapped to aid in the assessment of likelihood of occurrence (Figure 4.14).

A total of six conservation significant species were recorded during the current survey (section 4.4). A further four species are assessed as having a high likelihood of occurrence and four species as having a medium likelihood of occurrence. The remaining seven species are considered to have a low likelihood of occurrence (Table 4.3).

Species that were recorded or assessed as having a high or medium likelihood of occurrence are discussed in further detail in section 5.3. Species assessed as low likelihood of occurrence are not discussed further.

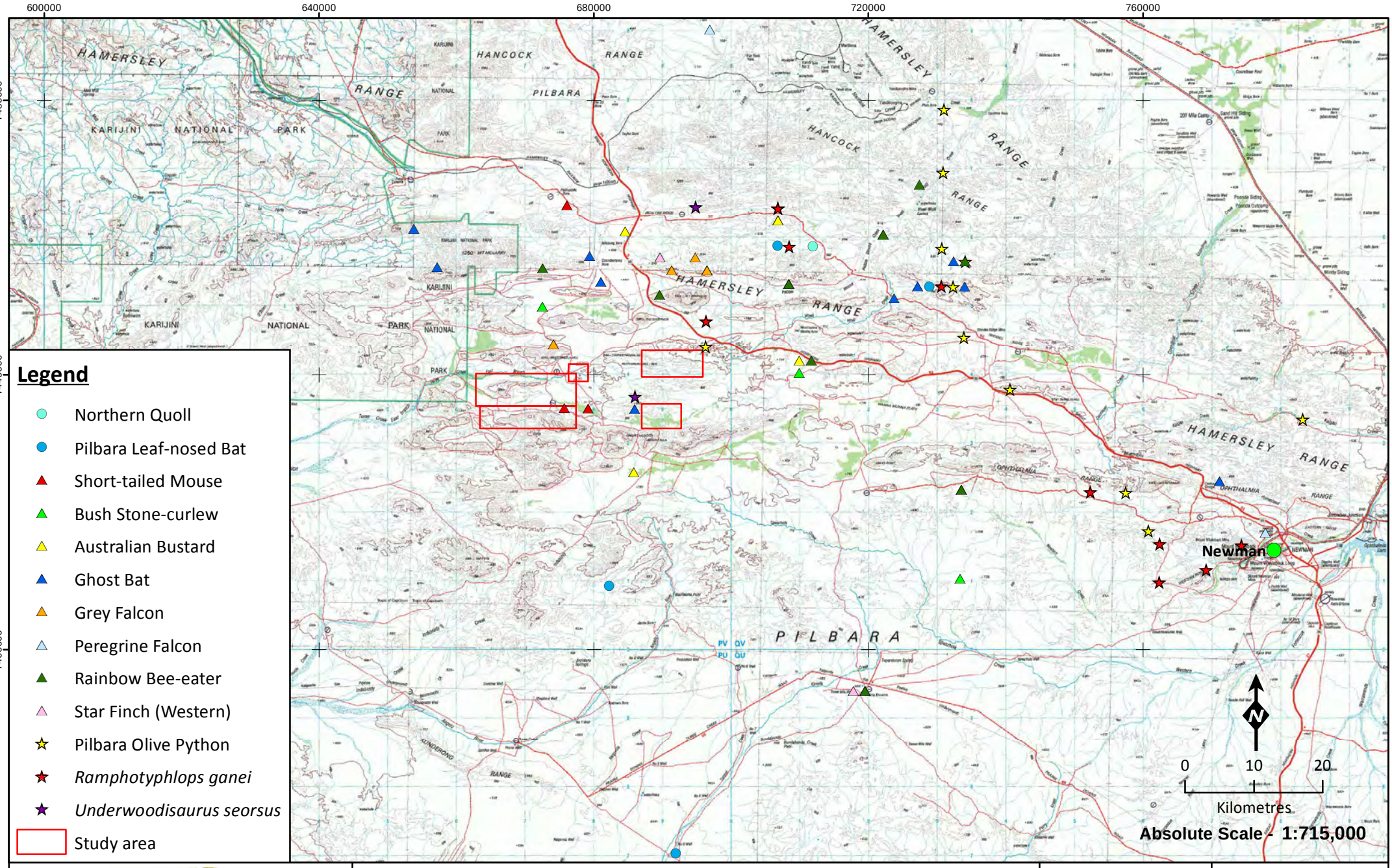
**Table 4.3 – Likelihood of occurrence status of potential conservation significant vertebrate fauna**

| Species | Conservation Significance | | | Habitat | Previous Records | Likelihood of Occurrence |
|---|---|---|---|---|---|---|
| | EPBC Act | WC Act | DEC | | | |
| **Mammals** | | | | | | |
| Northern Quoll<br>*Dasyurus hallucatus* | EN | S1 | EN | In the Pilbara, most common on dissected rocky escarpments, but also found in eucalypt forest and woodland. Typically rocky areas with suitable denning sites and access to surface water. | Three records from one location approx. 20 km north-east of study area from 2010 (DEC 2013). | **MEDIUM**<br>Some suitable habitat present within the study area and recent record within 20 km. |
| Greater Bilby<br>*Macrotis lagotis* | VU | S1 | VU | Variety of habitats on soft soil including spinifex hummock grassland, acacia shrubland, open woodland and cracking clays. | Secondary evidence recorded during two previous surveys within 30 km (ecologia internal database, Ninox 1995). Not recorded on NatureMap within 100 km (DEC 2013). | **LOW**<br>Low quality habitat present with lack of confirmed records close by. |
| Pilbara Leaf-nosed Bat<br>*Rhinonicteris aurantia* (Pilbara form) | VU | S1 | VU | Roost in caves with high humidity (95%) and temperature (32°C). Forage along water bodies with fringing vegetation. | Previous records from three locations within 30 km of the study area (DEC 2013). | **RECORDED**<br>Foraging individuals recorded during this survey, no roost cave recorded. |
| Ghost Bat<br>*Macroderma gigas* | | | P4 | Roost in caves, rock piles and abandoned mines. Will travel 2 km from roost to hunt. | Calls and potential roost caves were previously recorded in close proximity to the study area (*ecologia* internal database). | **HIGH**<br>Suitable hunting and roosting habitat is present within the study area. Species has been recorded previously. |
| Short-tailed Mouse<br>*Leggadina lakedownensis* | | | P4 | Spinifex and tussock grassland on cracking clays. Also acacia shrubland, samphire, woodlands, and stony ranges. | One previous record from within the study area from 1997 and three additional records from within 80 km area (DEC 2013). | **HIGH**<br>Species was recorded from within the study area in 1997 (DEC 2013). Not recorded during this survey. Suitable habitat present. |
| Western Pebble-mound Mouse<br>*Pseudomys chapmani* | | | P4 | Footslopes of rocky ranges and rocky hills where the ground has continuous small pebbles and vegetated by spinifex. | Previously recorded throughout the region (DEC 2013) and during 12 surveys in the region (Ninox 1994; HGM 1999a, ecologia internal database, Ninox 2009a, 2009b, Biota 2010; 1999b; Maunsell 2003). | **RECORDED**<br>Numerous active and inactive mounds were recorded within the study area during the survey. |

| Species | Conservation Significance | | | Habitat | Previous Records | Likelihood of Occurrence |
|---|---|---|---|---|---|---|
| | EPBC Act | WC Act | DEC | | | |
| **Birds** | | | | | | |
| Night Parrot<br>*Pezoporus occidentalis* | EN | S1 | CR | Mostly ground-dwelling; spinifex grasslands or samphire and chenopod shrublands near water bodies. | Recorded from Protected Matters Search only with no specific record information. . | **LOW**<br>Ecology poorly known and rarely recorded. |
| Fork-tailed Swift<br>*Apus pacificus* | M | S3 | | Nomadic, almost entirely aerial lifestyle over a variety of habitats; associated with storm fronts. | Recorded during one survey within 40 km of the study area (*ecologia* internal database). | **RECORDED**<br>Recorded during the survey. |
| Rainbow Bee-eater<br>*Merops ornatus* | M | S3 | | Open country, most vegetation types, dunes, banks; prefer lightly wooded, preferably sandy, country near water. | Recorded during the majority of previous surveys within 50 km of the study area (Biota 2010,Ninox 1994; HGM 1999a, b; Maunsell 2003) | **HIGH**<br>Suitable habitat present within study area. Numerous previous records. |
| Eastern Great Egret<br>*Ardea modesta* | M | S3 | | Wide range of wetland habitats, including floodwaters, rivers, shallows of wetlands, intertidal mudflats. | One location record within vicinity of study area (Maunsell 2003). | **LOW**<br>Typical wetland habitat absent within study area. |
| Cattle Egret<br>Ardea ibis | M | S3 | | Grassy habitats, shallow wetlands and water bodies, particularly damp pastures. | Recorded from Protected Matters Search only with no specific record information. | **LOW**<br>Typical wetland habitat absent within study area. |
| Oriental Plover<br>*Charadrius veredus* | M | S3 | | Open plains, including samphire; bare rolling country; bare claypans; open ground near inland swamps. | Recorded from Protected Matters Search only with no specific record information. | **LOW**<br>Suitable habitat exists but no previous records. |
| Common Sandpiper<br>*Actitis hypoleucos* | M | S3 | | Coastal and inland wetlands, with varying levels of salinity; mostly found on muddy margins or rocky shores; rarely mudflats. | One location record within vicinity of study area (Maunsell 2003). | **LOW**<br>Typical wetland habitat absent within study area. |
| Grey Falcon<br>*Falco hypoleucos* | | S1 | VU | Lightly wooded coastal and riverine plains. | Previously recorded close by (*ecologia* internal database) and four recent records close by (DEC 2013). | **MEDIUM**<br>Suitable foraging habitat present within study area but infrequently recorded species. |

| Species | Conservation Significance | | | Habitat | Previous Records | Likelihood of Occurrence |
|---|---|---|---|---|---|---|
| | EPBC Act | WC Act | DEC | | | |
| Peregrine Falcon<br>*Falco peregrinus* | | S4 | Other | Widespread; coastal cliffs, riverine gorges and wooded watercourses. | Recorded during two previous surveys within 50 km of the study area (ecologia internal database, Ninox 1994). Three additional records on NatureMap within 100 km (DEC 2013). | **MEDIUM**<br>Suitable foraging and nesting habitat present within study area. |
| Australian Bustard<br>*Ardeotis australis* | | | P4 | Open grasslands, chenopod flats and low heathland. | Recorded during seven previous surveys within 50 km of the study area (Ninox 1994, 1995; HGM 1999a, 2009a, 2009b, ecologia internal database; 1999b). | **RECORDED**<br>Recorded during this survey. |
| Bush Stone-curlew<br>*Burhinus grallarius* | | | P4 | Lightly wooded country next to daytime shelter of thickets or long grass. | Three records within 50 km of the study area (DEC 2013). | **RECORDED**<br>Tracks recorded during this survey. |
| Star Finch (western)<br>*Neochmia ruficauda clarescens* | | | P4 | Vegetation around watercourses, particularly thick reed beds. | A few previous records (Biota2010, ecologia internal database). | **LOW**<br>Typical wetland habitat absent within study area. |
| **Reptiles** | | | | | | |
| Pilbara Olive Python<br>*Liasis olivaceus barroni* | VU | S1 | VU | Watercourses and areas of permanent water in rocky gorges, escarpments and gullies. | Eight records within 50 km with the closest one within 1 km to the north-east of the study area (DEC 2013). Recorded during three previous surveys in the local region (ecologia internal database,HGM 1999b; Maunsell 2003) | **HIGH**<br>Some suitable habitat present and some previous records close by. |
| *Ramphotyphlops ganei* | | | P1 | Variety of habitats; thought to prefer moist gorges. | Eleven records within 100 km, recent and historic (DEC 2013). | **MEDIUM**<br>Suitable habitat present and some previous records close by. |
| Pilbara Barking Gecko<br>*Underwoodisaurus seorsus* | | | P1 | Rocky gorges and rock piles. | Type locality close by, two records within 20 km of the study area (DEC 2013). | **RECORDED**<br>Recorded during this survey |

Note: Description of conservation significant codes provided in Appendix A.




ecologia ENVIRONMENT

# Regional conservation significant vertebrate fauna records

**Figure: 4.14**
**Project ID: 1458**

**Drawn: BG**
**Date: 26/04/2013**

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

Unique Map ID: BG311

**A4**

## 4.4 CONSERVATION SIGNIFICANT VERTEBRATE FAUNA RECORDED

Based on database searches and the results of previous biological surveys in the surrounding region, 6 mammal, 12 bird and 3 reptile species of conservation significance could potentially occur in the study area. Six species of conservation significance (two mammal, three bird and one reptile species) were recorded from within the study area, these records are summarised in Table 4.4 and mapped in Figure 4.15 and Figure 4.15.

**Table 4.4 – Conservation significant fauna recorded during the survey**

| Species | Location | | | Comments* |
|---|---|---|---|---|
| | Easting | Northing | Site | |
| **Mammals** | | | | |
| Pilbara Leaf-nosed Bat | 671504 | 7435248 | GWA S10 | Single call on the 23/3/13 in middle of night indicating foraging individual. |
| Pilbara Leaf-nosed Bat | 666240 | 7436475 | GWA S7 | Four calls on the 24/3/13 at different times of night indicating possibly more than one foraging individual. |
| Pilbara Leaf-nosed Bat | 667740 | 7439331 | GWA S12 | Single call on the 23/3/13 in middle of night indicating foraging individual. |
| Western Pebble-mound Mouse | 673665 | 7434462 | Opportunistic | Active mound |
| Western Pebble-mound Mouse | 672596 | 7434480 | Opportunistic | Active mound |
| Western Pebble-mound Mouse | 668157 | 7434280 | Opportunistic | Active mound |
| Western Pebble-mound Mouse | 672684 | 7434543 | Opportunistic | Active mound |
| Western Pebble-mound Mouse | 667710 | 7439402 | Opportunistic | Active mound |
| Western Pebble-mound Mouse | 675011 | 7434825 | Opportunistic | Active mound |
| Western Pebble-mound Mouse | 667803 | 7439414 | Opportunistic | Active mound |
| Western Pebble-mound Mouse | 666190 | 7436653 | Opportunistic | Active mound |
| Western Pebble-mound Mouse | 669120 | 7434586 | Opportunistic | Active mound |
| Western Pebble-mound Mouse | 669037 | 7434650 | Opportunistic | Active mound |
| Western Pebble-mound Mouse | 668923 | 7437248 | Opportunistic | Active mound |
| Western Pebble-mound Mouse | 668627 | 7434577 | Opportunistic | Active mound |
| Western Pebble-mound Mouse | 689675 | 7442560 | Opportunistic | Active mound |
| Western Pebble-mound Mouse | 677258 | 7438166 | Opportunistic | Active mound |
| Western Pebble-mound Mouse | 668967 | 7438036 | Opportunistic | Active mound |
| Western Pebble-mound Mouse | 666396 | 7434452 | Opportunistic | Active mound |
| Western Pebble-mound Mouse | 677714 | 7440975 | Opportunistic | Active mound |
| Western Pebble-mound Mouse | 690176 | 7440478 | Opportunistic | Active mound |
| Western Pebble-mound Mouse | 671568 | 7435429 | Opportunistic | Active mound |
| Western Pebble-mound Mouse | 671561 | 7435088 | Opportunistic | Active mound |
| Western Pebble-mound Mouse | 671480 | 7435074 | Opportunistic | Inactive mound |
| Western Pebble-mound Mouse | 668034 | 7434428 | Opportunistic | Inactive mound |
| Western Pebble-mound Mouse | 666413 | 7434675 | Opportunistic | Inactive mound |
| Western Pebble-mound Mouse | 670747 | 7436275 | Opportunistic | Inactive mound |
| Western Pebble-mound Mouse | 671842 | 7434792 | Opportunistic | Inactive mound |
| Western Pebble-mound Mouse | 687618 | 7441807 | Opportunistic | Inactive mound |

| Species | Location | | | Comments* |
|---|---|---|---|---|
| | Easting | Northing | Site | |
| Western Pebble-mound Mouse | 676489 | 7433398 | Opportunistic | Inactive mound |
| Western Pebble-mound Mouse | 676600 | 7433391 | Opportunistic | Inactive mound |
| Western Pebble-mound Mouse | 664911 | 7437248 | Opportunistic | Inactive mound |
| Western Pebble-mound Mouse | 690846 | 7442070 | Opportunistic | Inactive mound |
| **Birds** | | | | |
| Fork-tailed Swift | 666240 | 7436475 | GWA S7 | Large flock of 400 individuals |
| Fork-tailed Swift | 666240 | 7436475 | GWA S7 | 40 individuals |
| Fork-tailed Swift | 687325 | 7432923 | GWA S3 | 10 individuals |
| Fork-tailed Swift | 690270 | 7434157 | GWA S4 | 70 individuals |
| Fork-tailed Swift | 678869 | 7433283 | Opportunistic | Eight individuals |
| Fork-tailed Swift | 673382 | 7440840 | Opportunistic | 15 individuals |
| Fork-tailed Swift | 687325 | 7432923 | GWA S3 | 10 individuals |
| Australian Bustard | 683491 | 7441236 | Opportunistic | 1 individual |
| Australian Bustard | 673255 | 7440353 | Opportunistic | 1 individual |
| Australian Bustard | 671862 | 7439462 | Opportunistic | 1 individual |
| Bush Stone-curlew | 687166 | 7433154 | GWA S3 | Tracks only |
| **Reptiles** | | | | |
| *Underwoodisaurus seorsus* | 690650 | 7441655 | GWA S1 | One individual captured |

Zone 50K;

Datum WGS 84

*Individuals = animals seen at the same time and, therefore, numbers are confirmed. Records = may be separate bird surveys or different days at a trap site and, therefore, some individuals may have been observed multiple times.

## 4.5 INVERTEBRATE SHORT RANGE ENDEMIC FAUNA RECORDED

A total of 33 species from six different Orders were submitted for identification and for SRE status assessment. A total of 15 species were identified as potential SRE species. The results and SRE status of submitted specimens are summarised in Table 4.5, with the location of potential SRE species mapped in Figure 4.16.

The results of potential SRE specimens submitted comprised the following: four species from two families of spiders (two potential SRE), six species from two families of scorpions (one potential SRE), 10 species from two families of isopods (six potential SRE), five species from three families of snails (no SRE), five species from one family of pseudoscorpions (four potential SRE) and three species from three families of millipedes and centipedes (two potential SRE).

**Table 4.5 – SRE fauna results**

| Higher Taxon | Species | SRE status | Individuals (M/F/J)* | Method | Site^ |
|---|---|---|---|---|---|
| **Mygalomorphae (trapdoor spiders)** | | | | | |
| **Barychelidae** | *Aurecocrypta* sp. indet. | Potential | 0/0/1 | Opportunistic capture | GWA S11 |
| | *Synothele* 'MYG127' | Not SRE | 1/0/0 | Dry pitfall | GWA S2 |
| **Nemesiidae** | *Aname mellosa* | Not SRE | 2/0/0 | Dry pitfall | GWA S10 |
| | *Yilgarnia* 'MYG197' | Potential | 1/0/0 | Dry pitfall | GWA S7 |
| **Scorpiones (scorpions)** | | | | | |
| **Buthidae** | *Lychas* sp. 'harveyi' | Not SRE | 7/1/0 | Dry pitfall | GWA S3, S4 ,S5, S10, S11, S12 |
| | *Lychas* sp. 'pilbara1' | Not SRE | 15/1/1 | Dry pitfall | GWA S1, S2, S4, S5, S9 |
| | *Lychas bituberculatus* | Not SRE | 0/2/0 | Dry pitfall | GWA S7 |
| | *Lychas* sp. 'hairy tail' | Not SRE | 1/0/0 | Dry pitfall | GWA S2 |
| | *Isometroides* 'pilbara1' | Not SRE | 1/0/0 | Dry pitfall | GWA S8 |
| **Urodacidae** | *Urodacus* sp. indet. | Potential | 0/0/10 | Targeted dry pitfall | GWA Opp, S3 |
| **Isopoda (Isopods)** | | | | | |
| **Armadillidae** | *Buddelundia* sp. nov. '10 1458A' | Potential | 33/35/2 | Dry pitfall | GWA S1, S2, S3, S4, S5, S6, S7, S9, S10, S12 |
| | *Buddelundia* sp. nov. '10 1458B' | Potential | 5/4/0 | Dry pitfall | GWA S1, S5, S10, S11 |
| | *Buddelundia* sp. nov. '10 1458C' | Potential | 0/1/0 | Dry pitfall | GWA S1 |
| | *Buddelundia* sp. nov. '10 1458D' | Potential | 3/1/0 | Dry pitfall | GWA S2 |
| | *Buddelundia* sp. nov. '15' | Not SRE | 2/1/0 | Dry pitfall | GWA S3, S4, S7 |
| | *Buddelundia* sp. nov. '16' | Not SRE | 5/7/2 | Dry pitfall, forage | GWA S1, S2, S6, S7, Opp |
| | *Buddelundia* sp. nov. '68WA' | Potential | 1/1/0 | Dry pitfall, forage | GWA S5, FS1 |
| | Buddelundinae genus ident. Buddelundinae 'PES999' | Not SRE | 1/5/0 | Dry pitfall | GWA FS4, S4, S6 |
| | New genus. (close to *Buddelundia*) sp. nov. '1' | Not SRE | 1/3/0 | Dry pitfall | GWA S5, S8, S10 |

| Higher Taxon | Species | SRE status | Individuals (M/F/J)* | Method | Site^ |
|---|---|---|---|---|---|
| **Unknown** | Genus indet. sp. indet. | Potential | 1/0/0 | Dry pitfall | GWA S5 |
| **Molluscs (Snails)** | | | | | |
| **Bothriembryontidae** | *Bothriembryon* sp. nov. 'Pilbara' | Not SRE | 4 | Leaf litter | GWA FS4 |
| **Pupilidae** | *Gastrocopta mussoni* | Not SRE | 12 | Leaf litter | GWA FS3, FS4 |
| | *Gastrocopta* cf. *hedleyi* | Not SRE | 12 | Leaf litter | GWA S1 |
| | *Pupoides* cf. *pacificus* | Not SRE | 11 | Leaf litter | GWA FS4, S9, S12 |
| **Subulinidae** | *Eremopeas interioris* | Not SRE | 15 | Leaf litter | GWA S1, S2 |
| **Pseudoscorpiones (Pseudoscorpions)** | | | | | |
| **Olpiidae** | *Beierolpium* sp. indet. | Potential | 0/0/1 | Leaf litter | GWA S1 |
| | *Euryolpium* sp. indet. | Potential | 0/0/1 | Leaf litter | GWA S3 |
| | *Indolpium* sp. indet. | Unlikely | 1/0/0 | Leaf litter | GWA S11 |
| | *Xenolpium* sp. indet. | Potential | 5/4/1 | Dry pitfall, Leaf litter | GWA S1, S2, S5, S7, S9, S11, FS4 |
| | Genus indet. sp. indet. | Potential | 0/0/3 | Dry pitfall, forage | GWA Opp, S1, S6 |
| **Diplopoda (Millipedes and centipedes)** | | | | | |
| **Trigoniulidae** | *Austrostrophus stictopygus* | Not SRE | 3/3/3 | Forage | GWA Opp, S2 |
| **Geophilidae** | Genus ident. sp. indet. | Potential | 0/0/1 | Forage | GWA S2 |
| **Chilenophilidae** | Genus ident. sp. indet. | Potential | 0/0/1 | Forage | GWA S2 |

*M=Male, F=Female, J=Juvenile

^Site FS = Forage Site

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665000 670000 675000 680000 685000 690000 695000

7440000 7435000 7430000 7425000

Deposit I
Deposit C
Deposit D
Deposit G
Deposit B
Deposit H
Deposit A
Deposit E
Deposit F
Mt Ella
Mt Ella

## Legend

- Pilbara Leaf-nosed Bat
- Western Pebble-mound Mouse (Active mound)
- Western Pebble-mound Mouse (Inactive mound)
- Fork-tailed Swift
- Australian Bustard
- Bush Stone-curlew (tracks)
- *Underwoodisaurus seorsus*
- Deposit area
- Study area

N

0 2 4

Kilometres

**Absolute Scale - 1:90,000**

ecologia ENVIRONMENT

# Conservation significant fauna recorded

**Figure: 4.15**
**Project ID: 1458**

**Drawn: BG**
**Date: 24/9/2013**

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

Unique Map ID: BG306

**A3**

655000 660000 665000 670000 675000 680000 685000 690000 695000

7445000 7440000 7435000 7430000 7425000

Deposit I

Deposit B

Deposit H

Deposit C

Deposit G

Deposit D

Mt Ella

Deposit A

Deposit E

Deposit F

## Legend

### Species

- *Aurecocrypta* sp. indet.
- *Beierolpium* sp. indet.
- *Buddelundia* sp. nov. '10 1458A'
- *Buddelundia* sp. nov. '10 1458B'
- *Buddelundia* sp. nov. '10 1458C'
- *Buddelundia* sp. nov. '10 1458D'
- *Buddelundia* sp. nov. '68WA'
- Chilenophilidae genus indet. sp. indet.
- *Euryolpium* sp. indet.
- Geophilidae genus indet. sp. indet.
- Isopod genus indet. sp. indet.
- Olpiidae genus indet. sp. indet.
- *Urodacus* sp. indet.
- *Xenolpium* sp. indet.
- *Yilgarnia* 'MYG197'
- Deposit area
- Study area

N

0 2.5 5

Kilometres

**Absolute Scale - 1:107,000**

ecologia ENVIRONMENT

# Potential SRE fauna recorded

**Figure: 4.16**
**Project ID: 1458**

**Drawn: BG**
**Date: 24/9/2013**

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

Unique Map ID: BG305

**A3**

# 5 DISCUSSION

## 5.1 BROAD-SCALE HABITATS

### 5.1.1 EPBC listed species habitat

Habitat types were assessed for their suitability for EPBC Act listed conservation significant fauna that were recorded or assessed as medium or high likelihood of occurrence within the study area (Northern Quoll, Pilbara Leaf-nosed Bat, Fork-tailed Swift, Rainbow Bee-eater and Pilbara Olive Python). Detailed descriptions of the suitability of potential habitats identified for each species within the study area and the extent of these within the study area are summarised in Table 5.1 below.

**Table 5.1 – Summary of potential habitats for EPBC Act listed fauna within the study area**

| Species | Fauna Habitat | Area inside study area (ha) | Percentage of Total study area (%) |
|---|---|---|---|
| Northern Quoll | **Potential denning habitat**. Areas of rocky gorges and gullies in the study area that may contain suitable den sites, preferably near a water source (Oakwood 2002). | 1.70 | 0.97 |
| | **Foraging/dispersal habitat**. Well-vegetated and/or rocky areas used for foraging/hunting, often associated with a creekline or river system, as well as habitat traversed by the species when moving from potential denning areas to suitable foraging areas and when seeking mates during the breeding season (Oakwood 2000) (includes footslopes and plains). | 63.46 | 36.13 |
| Pilbara Leaf-nosed Bat | **Potential roosting/breeding habitat**. Areas of rocky gorges and gullies in the study area that may contain suitable caves for roosting (Armstrong 2001). | 1.70 | 0.97 |
| | **Foraging habitat**. Habitat over which the species may fly while foraging, preferably well-vegetated areas, often associated with water and open valleys, which attract a higher number of insects (Armstrong 2008). | 80.88 | 46.05 |
| Fork-tailed Swift | **Potential nesting habitat**. This migratory species only breeds in north-east and mid-east Asia, and spends the winter in Australia (Johnstone and Storr 1998). Hence no nesting habitat can be impacted upon. | 0 | 0 |
| | **Foraging habitat**. This species is completely aerial while in Australia (Johnstone and Storr 1998), so does not directly utilise land or habitats. However, landform features such as valleys can have concentrations of aerial insects, which in turn attract this species. | 175.65 | 100 |
| Rainbow Bee-eater | **Potential nesting habitat**. The Rainbow Bee-eater nests in burrows usually dug at a slight angle on flat ground, sandy banks or cuttings (Boland 2004), with this habitat commonly found within major drainages. | 0.51 | 0.29 |

| | | | |
|---|---|---|---|
| | **Foraging habitat**. The Rainbow Bee-eater forages in a wide variety of habitats. Generally closely associated to major drainages or areas of woodland habitat (Boland 2004). | 2.21 | 1.26 |
| Pilbara Olive Python | **Potential critical habitat**. Areas that may contain escarpments, gorges, preferably with rock crevices and outcrops near water holes, which attract prey species (Pearson 2003). | 1.70 | 0.97 |

### 5.1.2 Footslope and plain

The mammal species of the footslopes and plains comprise a variety of generalists such as the Little Red Kaluta (*Dasykaluta rosamondae*), Pilbara Ningaui (*Ningaui timealeyi*), Planigale (*Planigale* sp.) and Euro (*Macropus robustus*).

The avifauna of this habitat type is relatively poor due to the low density of the tree and shrub layer. Bird species that can be found in this habitat include generalists such as Zebra Finch, Painted Finch, Diamond Dove, Little Button-Quail and Spinifex Pigeon. Footslopes and plains can also include patches of moderately dense to dense shrubs that can attract a moderate number of bird species such as Singing Honeyeater, Masked Woodswallow, Black-faced Woodswallow, and Variegated Fairy-wren. Birds of prey utilise the open vegetation for hunting and Brown Falcons, Spotted Harriers and Whistling Kite can often be seen foraging above the spinifex plains.

The herpetofauna of the foothills and plains comprises a range of generalists that find shelter and shade under spinifex clumps, as the usually hard soil and rocks do not allow the construction of burrows. These include the skink *Lerista verhmens*, Rock Ctenotus (*Ctenotus saxatilis*), Leopard Ctenotus (*Ctenotus pantherinus*), Ring-tailed Dragon (*Ctenophorus caudicinctus*), Spiny-tailed Monitor (*Varanus acanthurus*), Pilbara Death Adder (*Acanthophis wellsi*), Moon Snake (*Furina ornata*), the legless lizard *Delma nasuta* and Central Blue-tongue Lizard (*Tiliqua multifasciata*).

The SRE invertebrate species inhabiting footslope and plain usually comprise mygalomorph (trapdoor) spiders (particularly from the families Idiopidae, Nemesiidae, Barychelidae and Dipluridae), scorpions, pseudoscorpions and isopods. Most SRE invertebrates prefer the southern footslopes where sun exposure is reduced and the level of moisture under shrubs and trees is increased (Main 1996; Main 1999). Some spiders from the family Idiopidae build their burrows on the flood plain, sealing their burrows at times of inundation.

Footslopes and plains were assessed as comprising suitable foraging habitat for the EPBC Act listed Pilbara Leaf-nosed Bat. Footslopes and plains are also preferred habitat for two other species of conservation significance: the Western Pebble-mound Mouse and the Australian Bustard, the latter of which is generally restricted to the plains and rarely occurs along the footslopes.

### 5.1.3 Hilltop, hillslope, ridge and cliff

The mammals of this habitat type typically comprise the Common Rock-rat (*Zyzomys argurus*), Woolley's False Antechinus (*Pseudantechinus woolleyae*), and Rothschild's Rock-Wallaby (*Petrogale rothschildi*). These species shelter in caves and crevices. The cliff faces of this habitat type also support cave structures that provide roosting habitat for a variety of bat species.

The avifauna of the hilltops, hillslopes, ridges and cliffs is of low variety and can includes a number of generalists such as the Painted Finch and the Spinifexbird and some specialised bird species such as the Striated Grasswren and Rufous-crowned Emu-wren. Cliffs can be inhabited by the Southern Boobook, which will utilise overhangs and caves for nesting. However, this habitat type generally

consists of open vegetation with limited dense vegetation cover from shrubs or trees and therefore birds inhabiting this habitat type typically live within or between the spinifex clumps.

The herpetofauna of this habitat type can vary between the four individual habitat subtypes that make up this habitat type. These are divided into the hilltops habitat subtype, the hillslopes habitat subtype, ridges habitat subtype, and cliffs habitat subtype. Species typically inhabiting the hilltops habitat subtype include generalists such as the Fat-tailed Gecko (*Diplodactylus conspicillatus*) and the geckos *Lucasium wombeyi* and *Heteronotia binoei*. The herpetofauna of the hillslopes habitat subtype and ridges habitat subtype usually comprises the skinks *Ctenotus saxatilis* and *C. rutilans*. The cliff habitat subtype is a fauna habitat that is typically inhabited by specialised reptile species such as the Pilbara Rock Monitor (*Varanus pilbarensis*), the Pygmy Python (*Antaresia perthensis*) and the Desert Cave Gecko (*Heteronotia spelea)*.

Regarding the SRE invertebrate fauna, hilltops, hillslopes, ridges and cliffs habitat type often lacks the microhabitats suitable for this fauna due to their exposed nature, often coupled with reduced layer of soil and leaflitter. However, isopods, pseudoscorpions and some mygalomorph spiders from the family Dipluridae may be found in this habitat type.

In addition, the hilltops, hillslopes, ridges and cliffs habitat type is of medium value for the *EPBC Act* listed Northern Quoll (foraging/dispersal habitat). This habitat type provides some suitable habitat for shelter and foraging, but also supports the conservation significant Pilbara Barking Gecko (*Underwoodisaurus seorsus*). Cliff faces can also provide suitable breeding habitat for the Peregrine Falcon (WC Act Schedule 4) and the Grey Falcon (WC Act Schedule 1).

### 5.1.4 Mixed Acacia woodland

The mammal species inhabiting mixed acacia woodlands include generalists and the patches of this habitat type recorded in the study area were of relatively large size. The Pilbara Ningaui, Planigale, and Euro are all common inhabitants of the mixed acacia woodlands habitat type.

The avifauna of the acacia woodland is usually most diverse after significant rainfall, and when acacia shrubs and trees are flowering. In particular, honeyeater species such as the Singing Honeyeater, Grey-headed Honeyeater and Crimson Chat were recorded and, in good conditions, Black-chinned and White-fronted Honeyeater can be common. Other species also occurred, including Crested Bellbird, Red-capped Robin, Grey-crowned Babbler, White-winged Triller, Chestnut-rumped Thornbill and Willie Wagtail. The presence of some of these species, such as Crested Bellbird, Grey-crowned Babbler, and Chestnut-rumped Thornbill, is less dependent on rainfall and flowering events, as they are more sedentary than species like Black-chinned and White-fronted Honeyeaters.

The herpetofauna of the mixed acacia woodland typically comprises mainly generalists, with species occurring along the foothills and plains such as the Tree Dtella (*Gehyra variegata*), the Spiny-tailed Geckos *Strophurus strophurus* and *S. wellingtonae*, and the skink *Menetia greyii*.

Some mygalomorph spiders are known to adapt to mixed Acacia shrublands, creating burrows beneath the shrubs, utilising their leaves and twigs to create elaborate trap door lids (family Idiopidae) or cryptic open burrows (family Nemessiidae) (Main 1985). Isopods often inhabit the leaflitter below the shrubs and trees and millipedes can be found in decaying logs.

*Acacia* woodland is known to provide a suitable habitat for the EPBC listed mygalomorph spider *Idiosoma* nigrum (Approved Conservation Advice for *Idiosoma nigrum* (shield-back spider), 2013), however the likelihood of the species occurring in the study area is low as the species is currently known to occur only in the Midwest and Wheatbelt regions.

### 5.1.5 Mesa top

The mammal diversity of the mesa is relatively poor due to the elevation and therefore the isolation from accessible surrounding habitats. However, mammal species that occupy the cliff faces and ridges can also occur on top of the mesas. These species include the Rothschild's Rock-wallaby, the Common Rock-rat and the Planigale. The two sites established on the mesa tops within the study area were located in an easily accessible section and therefore generalists such as the Little Red Kaluta, Pilbara Ningaui, Stripe-faced Dunnart, Ooldea Dunnart, Delicate Mouse, Desert Mouse and Sandy Inland Mouse were recorded.

The avifauna of the mesa top habitat shows a combination of species recorded in other habitat types. Typical woodland bird species, which are generally not recorded in hilly, rocky areas, were recorded in this habitat type, due to patches of dense woodland, in particular mulga (*A. aneura* complex), being present. Such bird species include the Tawny Frogmouth, Western Gerygone, Inland Thornbill, White-fronted Honeyeater, Spiny-cheeked Honeyeater and the Red-capped Robin.

The herpetofauna that can be found on mesa tops includes some generalists (*Gehyra variegata, Ctenotus pantherinus, C. helenae* and *C. saxatilis*). In addition, some specialists were found on the mesa top with dense shrubs such as the Pilbara Barking Gecko (*Underwoodisaurus seorsus*), the skink *Lerista zietz*i and the Southern Pilbara Beak-faced Gecko (*Diplodactylus savagei).*

Unlike the vertebrate fauna, the invertebrate fauna of mesa tops can be quite diverse and specialised. Many species with limited mobility can become "stranded" in this habitat type over time as the geological substrate around erodes. This is subsequently enhanced by the isolation of the mesa top elevation above the surrounding plain, presenting a potentially significant barrier to gene flow and thus enhancing processes of speciation by vicariance (Mayr 1942, 1959). If the mesa top habitat type contains suitable microhabitats (e.g. woodland with deep soil and litter beds, as in the study area) a number of groups can be expected to occur there. All groups of potential SRE invertebrates collected during the survey (mygalomorph spiders, scorpions, pseudoscorpions, isopods, diplopods and snails) were represented at least by one species in this habitat type.

Conservation significant species that are likely to occur on the mesa top include Long-tailed Dunnart (*Sminthopsis longicaudata*), Pilbara Barking Gecko and Western Pebble-mound Mouse.

### 5.1.6 Cracking clay

The cracking clay within the study area supported a relatively large number of Stripe-faced Dunnarts (*Sminthopsis macroura*) but also provided habitat for the Sandy Inland Mouse. The Common Rock-rat (*Zyzomys argurus*) was also recorded from this habitat type, which can be considered very unusual.

The avifauna of the cracking clay habitat is typically extremely sparse. The lack of shelter and cover in the form of shrubs and trees does not attract many bush bird species. However, some ground dwelling birds, such as the Crested Pigeon, Common Bronzewing, and some seed eaters, such as the Budgerigar, the Zebra Finch and the Painted Finch, were recorded feeding on seeding grass species. This, combined with the lack of shelter, attracts birds of prey such as the Whistling Kite and Spotted Harrier, which were recorded hunting on these plains. The Horsefields Bushlark was the only bird species recorded only within this habitat, which it is typically found in.

The herpetofauna of the cracking clay typically comprises ground dwelling species such as the Fat-tailed Gecko (*Diplodactylus conspicillatus*) and *Nephrurus wheeleri*. The Pebble Dragon (*Tympanocryptis cephalus*) is usually restricted to cracking clay, which was confirmed by the results of this survey.

The invertebrate fauna of cracking clay habitat is usually very sparse due to lack of moist microhabitats, with the exception of soil-dwelling species adapted to prolonged periods of hydration

and drought (e.g. some mygalomorph spiders from families Barychelidae and Idiopidae). While no spiders have been collected within this habitat type during the survey, a scorpion from the genus *Isometroides* has been recorded here. As this scorpion is a specialised predator of mygalomorph spiders and often takes shelter in the spider burrow following predation of the resident spider (Main 1956), the presence of mygalomorphs in this habitat type is implied. Isopods have also been recorded in this habitat type, which is somewhat surprising.

One species of conservation significance is strongly associated with the cracking clay habitat: the Northern Short-tailed Mouse, however, it was not recorded during the current assessment. The Australian Bustard can also be found in this open habitat type but is expected to not reside there due to the lack of shelter and cover.

### 5.1.7 Major gorge and gully

The mammals inhabiting major gorges and gullies include rock dwelling specialists such as Woolley's False Antechinus (*Pseudantechinus woolleyae*), Rothschild's Rock-wallaby (*Petrogale rothschildi*) and Common Rock-rat (*Pseudomys argurus*).

The avifauna of the gullies and gorges is relatively poor compared to other habitat types due to the sparse shrub and grass vegetation and the usually low number of flowering trees and shrubs. However, Grey Shrike-thrush, Western Bowerbird, Grey-headed Honeyeater, Black-faced Cuckoo-Shrike and Painted Finch can all be observed in large trees or near waterholes along gullies and gorges, in particular when water is present. Gorges and rocky areas are also favoured habitat for Little Woodswallows.

The typical herpetofauna of gorges and gullies includes unique species that are specialised for inhabiting this fauna habitat type. Reptile species include the Pilbara endemic skink *Egernia pilbarensis*, the skink *Egernia formosa*, Pilbara Rock Monitor (*Varanus pilbarensis*) and Russet Snake-eyed Skink (*Cryptoblepharus ustulatus*). In addition to reptiles, a few species of amphibian can be found in gorges in the Hamersley region. Microhabitats with moist soil, such as those found under logs, rocks and leaf litter in rocky gullies and gorges are suitable for the Gorge Toadlet (*Pseudophryne douglasi*).

Gorges and gullies are particularly suitable for invertebrate fauna as this habitat type often supports a high level of moisture and humidity. Millipedes, snails, pseudoscorpions and isopods can be found sheltering under rocks or in leaf litter while scorpions and mygalomorph spiders often inhabit areas with accumulated soil.

Gorges and gullies represent suitable, good quality habitat for three mammal species of conservation significance: the Northern Quoll (*Dasyurus hallucatus*), the Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*) and the Long-tailed Dunnart (*Sminthopsis longicaudata*). These species shelter in crevices and caves, and prey on the large number of insects found in gorge and gully areas. The blind snake *Ramphotyphlops ganei* is known to occur in rocky gullies. Gorges that contain water pools after rainfall events provide suitable conditions for the Pilbara Olive Python (*Liasis olivaceus barroni*).

### 5.1.8 Major drainage

Major drainage systems provide habitat for a large number of species. The mammals of this habitat include species that also occupy other habitats identified within the study area, such as Pilbara Ningaui, Planigale, Sandy Inland Mouse and Desert Mouse. In addition, the fauna assemblage of the major drainage system can also comprise more specialised species such as the Northern Brush-tailed Possum (*Trichosurus vulpecula arnhemensis*).

The herpetofauna of major drainage system typically includes generalists such as the skinks *Carlia munda*, *Ctenotus pantherinus* and *C. helenae*, as well as more specialised species such as the Long-nosed Dragon (*Amphibolurus longirostris*), which is almost restricted to this habitat type.

Major drainage systems provide suitable habitat for a variety of bird species that can be found in large numbers and variety due to the number of trees and density of the vegetation providing optimal food and shelter. Bird species typically found only along major creeklines include the White-plumed Honeyeater, Sacred Kingfisher, Little Corella, and Cockatiel.

The fringes of the major drainage systems are known to support a number of SRE invertebrate species because they provide an increased level of moisture seeping in from the main water course and shade from large trees associated with river banks. Mygalomorph spiders from families Ctenizidae, Idiopidae and Nemesiidae are typically found in this type of habitat, as well as snails (including fresh-water species from the genus *Gyraulus*), millipedes and isopods.

Species of conservation significance that are commonly found within major creeklines include the Bush Stone-curlew and the Rainbow Bee-eater. The Bush Stone-curlew hides in the vegetation and will forage along water pools and in the surrounding areas. The Rainbow Bee-eater is an inhabitant of the trees and larger shrubs and sometimes builds its nests in the sand banks.The major drainage systems were assessed as comprising potential foraging/dispersal habitat for Northern Quoll, foraging habitat for Pilbara Leaf-nosed Bat and potential critical habitat for the Pilbara Olive Python. Northern Quoll can use this habitat type seasonally, during the breeding season, for dispersal using suitable tree hollows as temporary denning sites.

### 5.1.9 Mulga woodland

The mammal assemblage of the Mulga woodland habitat type is not distinctly dissimilar to assemblages in the surrounding habitat types. Generalists were recorded such as the Pilbara Ningaui, Stripe-faced Dunnart, Ooldea Dunnart and Sandy Inland Mouse.

Avifauna assemblage within this habitat type, despite being only small in area, was distinctly different, with abundance and diversity generally higher than other habitat types. This is thought to be due to the dense woodland structure of this habitat type. Bird species recorded exclusively within this habitat type included the Brown Quail, Bush Stone-curlew, Splendid Fairy-wren, Chestnut-rumped Thornbill and Grey Honey eater. Species such as the White-browed Babbler, Red-capped Robin, Spiny-cheeked Honeyeater, Inland Thornbill, Western Gerygone and Budgerigar are species also typical of the Mulga woodland and were recorded from this habitat type during the current survey.

Reptile species that are typically unique to mulga woodlands include the two monitor lizards *Varanus bushi* and, *V. caudolineatus*, and the Mulga Dragon (*Caimanops amphiboluroides*). Of these, one species, *Varanus bushi*, was observed during the survey however there was no reptile species that was exclusively recorded from this habitat type.

Mulga woodland provides suitable habitat for many SRE invertebrates. Some mygalomorph spiders are known to adapt to this habitat, creating burrows beneath the shrubs, utilising their leaves and twigs to create elaborate trap door lids (family Idiopidae) or cryptic open burrows (family Nemessiidae) (Main 1985). Scorpions build their burrows in patches of soft soil and pseudoscorpions and isopods often inhabit the leaflitter below the shrubs and trees while millipedes can be found in decaying logs. Many individuals of the scorpion *Urodacus* sp. indet. were recorded in this habitat type. The softer, upper soil substrate allowed this species to dig their spiralling burrows, where they shelter during the day.

### 5.1.10 Cleared area

No fauna assemblage can be described for cleared areas as they are not a distinct habitat type. Some fauna species that occur in habitats surrounding the cleared areas can utilise theses spaces for foraging however the lack of vegetation cover makes them susceptible to predation. At night, nocturnal bird of prey can be seen foraging, such as the Spotted Nightjar, Owlet Nightjar and Bush Stone-curlew. Diurnal birds of prey also use these areas, hunting the open grounds for small skinks, snakes or the occasional mammal.

## 5.2 VERTEBRATE FAUNA ASSEMBLAGE

### 5.2.1 Mammals

A total of 25 mammal species were recorded during the current survey, from a potential 47 species identified from the literature review. When compared against previous surveys of the region (Appendix E), it can be seen that this survey recorded the highest number of mammal species, with the next highest being 18 species (Ninox 2009b).

Abundance of the mammal species recorded was generally regarded as moderate. Excluding bat species, the most numerous recorded species were the small rodents; Sandy Inland Mouse (73 records), Common Rock-rat (52 records), the introduced House Mouse (41 records) and small dasyurids; Stripe-faced Dunnart (35 records), Pilbara Ningaui (35 records) and Little Red Kaluta (34 records). The activity levels of the majority of bat species were recorded as low, with high activity levels recorded for Finlayson's Cave Bat GWA S3, S5 and S11 and Gould's Wattled Bat at GWA S2 (Appendix F).

Most mammal species recorded are regarded as habitat generalists. The exceptions being Rothschild's Rock Wallaby, which is typically restricted to rocky habitats (recorded opportunistically within major gorge and gully habitat type) and the Western Pebble-mound Mouse (recorded by secondary evidence only, within footslope or plain habitat type). This is reflected within the MDS plot (Figure 4.10) for terrestrial trappable fauna (which includes small mammals), which shows no obvious visual differentiation between fauna trapped and corresponding habitat types.

A total of seven Dingo individuals were recorded (three on phase 1, four on phase two, Appendix F). Visually it appeared these individuals were consistent with normal dingo (*Canis lupus dingo*) morphology, indicating little interbreeding with the domestic dog (*Canis lupus familiaris*), with one individual recorded on Phase 2 being the uncommon black colour variation.

Conservation significant mammal species recorded included the Western Pebble-mound Mouse (DEC P4), recorded by secondary evidence (pebble mounds) only, and the Pilbara Leaf-nosed Bat (EPBC VU, WC Act S1 and DEC VU). The recording of the Pilbara Leaf-nosed Bat is of note, as this species has not been recorded on any previous surveys of the region, with the literature review recording this species from database searches only (Appendix E).

Of interest was no records of the conservation significant Ghost Bat (DEC P4). This is despite the Ghost Bat being known to be present within the study area, with a number of roost caves in close proximity (further discussed in Section 5.3.1.3). Churchill (2008) notes the Ghost Bat does not exclusively hunt using echolocation, but also hunts by eyesight and passive listening. As a result this species is difficult to record using standard ultrasonic recording devices.

Habitats were generally assessed as in good condition with little degradation from introduced fauna such as cattle. Of the nine potential introduced mammal species, just two were recorded, the House Mouse (41 records) and European Rabbit (eight records).

The SAC completed for trappable mammal species indicates the majority of trappable mammals were recorded (Section 5.6).

### 5.2.2 Birds

In total, 80 species of bird were recorded from the study area. This is the highest total when compared to previous surveys of the region, with the next highest being 69 (Ninox 1994). The high diversity is likely a result of relatively large study area, large variety of fauna habitats and two phases of surveying, with significant rainfall occurring between phases (Section 2.1).

The family Meliphagidae was the most diverse group recorded during this survey, with nine (out of a potential 12, Appendix E) species recorded. Included in the recorded honeyeaters was the rarely recorded Grey Honeyeater. Regarded as a mulga woodland habitat specialist, this species was recorded from site GWA S3 second phase only (Appendix F). The most abundantly recorded honeyeater species was the Singing Honeyeater, recorded a total of 288 times. The generalist nature of this species is indicated by the fact it was recorded at every systematic trapping site (Appendix F).

The recording of 10 of the potential 15 birds of prey (family Accipitridae and Falconidae, Appendix E) indicates good prey availability resulting from generally favourably climatic (predominately rainfall) conditions and high food resources. This is supported by high counts of irruptive birds such as the Budgerigar (1,010 records) and Zebra Finch (840 records). The recording of the Fork-tailed Swift in high numbers (533 records) is a result of favourable weather conditions for this species experienced during Phase 2. Notable thunderstorm activity occurred resulting in the Fork-tailed Swift being present in high numbers, including one very large flock of 400 individuals recorded at one time from GWA S7 (Appendix F).

A total of seven Brown Quail were recorded on phase 1 from GWA S3 (Appendix F), with the literature review revealing previous records from NatureMap only (Appendix E). The Brown Quail has only very recently been recorded from the Hamersley Pilbara subregion, with Johnstone and Storr (1998) describing the Brown Quail distribution as restricted to the Pilbara coast in the vicinity of Port Hedland. The NatureMap database shows there is just one record further south than the location of the study area (DPaW 2013).

The good condition of mulga woodland habitat in the vicinity of site GWA S3 is indicated by a number of mulga habitat specialist bird species recorded at this site. Splendid Fairy-wren, Western Gerygone, Chestnut-rumped Thornbill, Inland Thornbill, Grey Honeyeater, White-browed Babbler and Red-capped Robin were all exclusively or predominately recorded from this site. The mulga woodland habitat type only occupies a very small proportion of the habitats within the study area (0.28%), but is significant in supporting the high diversity of avifauna recorded within the study area.

Bird species of conservation significance recorded within the study area were the Fork-tailed Swift (EPBC M, WC Act S3) Australian Bustard (DPaW P4) and Bush Stone-curlew (tracks only, DPaW P4).

The SAC completed for avifauna indicates the majority of avifauna potentially occurring within the study area was recorded (Section 5.6).

### 5.2.3 Herpetofauna

A total of 64 reptile species were recorded within the study area. When compared to previous surveys of the region, this is the highest number recorded, with the next highest being 41 (Ninox 2009b). This high diversity when compared to other surveys is likely due to a combination of factors, such as relatively large survey area, variety in habitat types and favourable weather (high temperatures) conditions.

Of particular note was the recording of the skink *Ctenotus robustus*. This species was recorded from within the cracking clay habitat type during Phase 2, with four individuals trapped at site GWA S8 only (Appendix F). As noted in Section 4.2.4, this record represents a range extension of approximately 120 km south for this species, based on records from NatureMap (DPaW 2013).

Other noteworthy records include the recording of the fossorial skinks *Lerista timida* and *Lerista verhmens*. These small skinks have not been previously recorded according to the literature review (Appendix E), however these species were previously regarded as *Lerista muelleri* until the species complex was revised in 2007 (Smith and Adams 2007). The literature review also did not record the Pilbara Bandy Bandy (*Vermicella snelli,* Appendix E), which had a single individual trapped at site GWA S11 during phase 1 (Appendix F). This species is endemic to the Pilbara region, but is rarely encountered due to being cryptic in nature, seldom foraging in open ground. Instead they are largely fossorial and spend the majority of their life cycle below ground hunting their main prey item, blind snakes (Wilson and Swan 2010).

High elapid (front fang venomous snakes) diversity was encountered during the current assessment, with a total of 10 of the potential 11 species recorded (Appendix E). Of this group, the Moon Snake was the most abundant, with a total of nine individuals recorded (Appendix F). In contrast, the other two snake families Typhlopidae (blind snakes) and Boidae (pythons) were poorly represented, with zero out of five and one out of four species recorded respectively (Appendix E).

No amphibian species were recorded from the survey. The literature review revealed a total of eight species potentially occurring within the study area (Appendix E). Some burrowing frog species may be present within the study area (for example *Cyclorana maini*), however a lack of significant rain immediately prior and during surveying resulted in these species remain under ground and undetectable.

The SAC completed for reptile species indicates the majority of trappable reptiles were recorded (Section 5.6).

## 5.3 CONSERVATION SIGNIFICANT VERTEBRATE FAUNA

Based on the literature review, six mammal, 12 bird and three reptile species of conservation significance could potentially occur in the study area. Conservation significant vertebrate fauna that were recorded or assessed as high to medium likelihood of occurrence (section 4.3) are described in detail below.

### 5.3.1 Mammals

#### 5.3.1.1 Northern Quoll (*Dasyurus hallucatus*)

**Conservation Status:** EPBC Act Endangered, WC Act Schedule 1 (Endangered).

**Distribution and Habitat:** The Northern Quoll formerly occurred across northern Australia, from the Pilbara region in Western Australia to south-eastern Queensland. A 75% reduction of available habitat occurred during the 20$^{th}$ century, so that the species is now restricted to the Pilbara and northern Kimberley in Western Australia, and a few discrete populations across the Northern Territory and eastern Queensland (Braithwaite and Griffiths 1994). Northern Quolls are most common on dissected rocky escarpments, but are also found in eucalypt forest and woodland (Oakwood 2008). They are both arboreal and terrestrial and use a variety of den sites, including rock crevices, tree hollows, logs, termite mounds, house roofs and goanna burrows (Oakwood 2000, 2008).

**Ecology:** Northern Quolls are the smallest of the Australian quolls. Northern Quolls are nocturnal and opportunistic omnivores feeding primarily on small vertebrates, large insects and soft fruits. Breeding tends to occur near creeklines, where individuals go to drink when water is available (Oakwood 2002).

The most common cause of adult mortality is predation by dingoes, feral cats, snakes, owls and kites (Maxwell *et al.* 1996; Oakwood 2008). Other causes of mortality include predation by domestic dogs,

motor vehicle strikes and pesticide poisoning. The level of predation is increased through the removal of groundcover by fire.

**Likelihood of Occurrence:** Medium. The Northern Quoll has been recorded three times from one location approximately 20 km north-east of study area in 2010 (DPaW 2013). These records are shown in Figure 4.14. The species was recorded from three more locations within 85 km of the study area, however the study area lies along the southern distribution limit of the Northern Quoll based on previous records (DPaW 2013). The major gorge and gully habitat represents suitable denning habitat for this species, within the micro-habitat of boulder piles and rock crevices. The hilltop, hillslope, ridge or cliff and major drainage system habitat types represent suitable foraging habitat, where Northern Quolls may occasionally occupy.

#### 5.3.1.2 Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia* (Pilbara form))

**Conservation Status:** EPBC Act Vulnerable, WC Act Schedule 1 (Vulnerable).

**Distribution and Habitat:** The Pilbara Leaf-nosed Bat is the Pilbara form of the Orange Leaf-nosed Bat (*Rhinonicteris aurantia*). While it is considered a separate form, formal reclassification has been hampered by the small sample size of the Pilbara population (Armstrong 2008).

Recent evidence suggests two main stronghold areas for the Pilbara Leaf-nosed Bat; in the western Pilbara and north of Marble Bar (Armstrong 2008). In the western Pilbara, they roost in caves formed in gorges that dissect siliceous sedimentary geology. They are most often observed in flight over waterholes in gorges, although they are rare even in the Hamersley Ranges where this habitat is common (Armstrong 2008). The Pilbara Leaf-nosed Bat roosts in disused mines and areas of high relief with gorges and watercourses (Armstrong 2001). They are unlikely to occur in the shallow 'breakaway' caves that occur along mesas and strike ridges.

**Ecology:** At dusk, Pilbara Leaf-nosed Bats emerge from their roosting sites to forage in gorges, small gullies and large watercourses for insects (van Dyck and Strahan 2008). They are susceptible to disturbance and will abandon roost caves if disturbed. Colonies in mines in the eastern Pilbara are subject to several pressures, including human visitation, and the collapse and flooding of disused mines (Armstrong 2008; DEWHA 2008b).

**Likelihood of Occurrence:** Recorded. The literature review indicates that this species has not been previously recorded within 30 km of the study area, with three previous records existing east and south of the study area (Appendix E, Figure 4.14). The study area is positioned further south then where this species has previously been regularly recorded, with just three previous records located south of these current records (DPaW 2013).

All records made indicate a foraging individual(s). The recording of four separate calls from site GWA S7 suggest potentially more than one individual present within the study area. The timing of calls in the middle of the night and a relatively low number of calls suggest the individual(s) have flown in to the study area from a roost location outside the study area. It is estimated that the Pilbara Leaf-nosed Bat has a maximum nightly foraging range of up to 10 km from their roost. This suggests a potential previously unknown roost site could be in relatively close proximity to the study area.

The Pilbara Leaf-nosed Bat is reliably detectable via echolocation call analysis, due to the high frequency of its call. The spectrogram showing the call frequency of the Pilbara Leaf-nosed Bat from GWA S7 is shown in Figure 5.1. This particular call had a peak frequency of 121,200 Hz, with all other potential microbat species of the Pilbara having a peak frequency ranging from a low of 11,400 Hz (White-striped Freetail Bat) to a high of 55,800 (Finlayson's Cave Bat) (McKenzie and Bullen 2009).

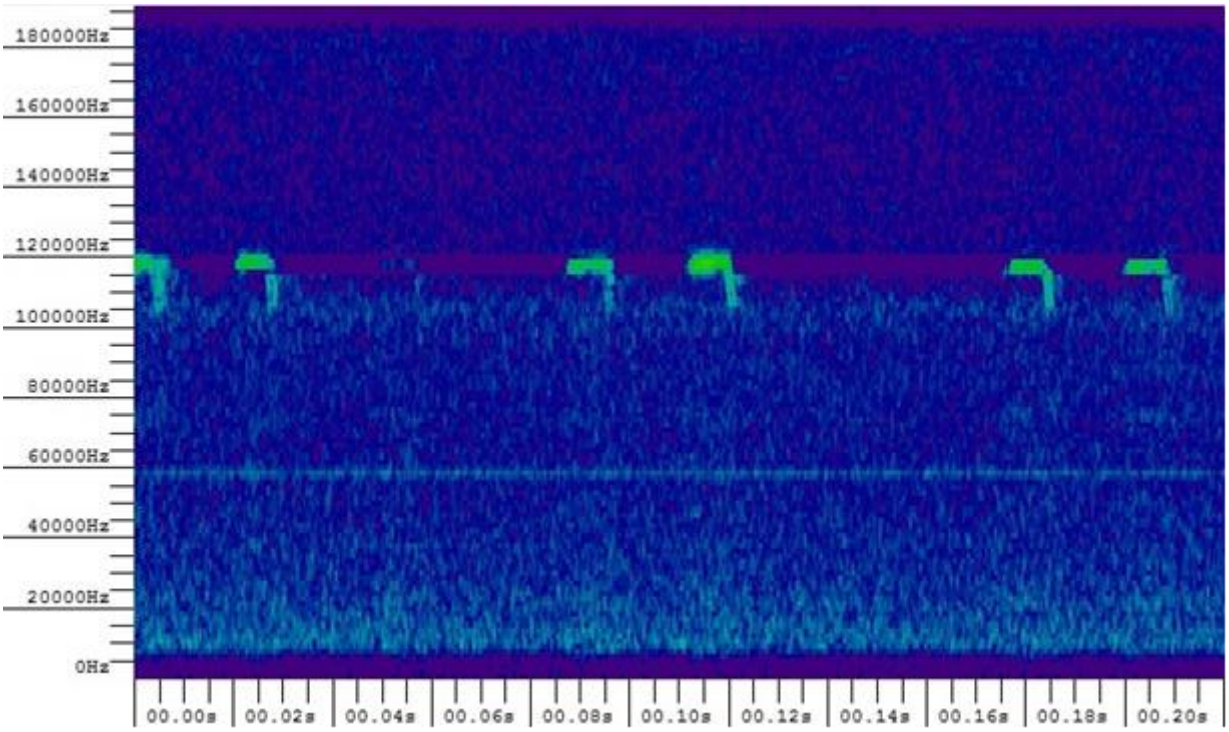



**Figure 5.1 – Spectogram showing call frequency of Pilbara Leaf-nosed Bat recorded**

#### 5.3.1.3 Ghost Bat (*Macroderma gigas*)

**Conservation Status:** DEC Priority 4.

**Distribution and Habitat:** The Ghost Bat has a patchy but widespread distribution across northern Australia. Preferred roosting habitats in the Pilbara include caves beneath bluffs of low, rounded hills composed of Marra Mamba geology, and granite rock piles. Ghost Bats have also been known to roost in large colonies within sandstone caves, under boulder piles and in abandoned mines (Churchill 1998). Ghost Bats disperse widely during the non-breeding season but require warm caves with high relative humidity (80%) when rearing their young (Toop 1985). These maternity caves are uncommon with only eleven recorded in the Pilbara region (three natural caves and eight mines) (Armstrong and Anstee 2000b).

**Ecology:** The Ghost Bat is carnivorous and takes prey to an established feeding site to be eaten. These feeding sites are usually a rock overhang or small cave, and are easily recognised by the accumulation of discarded prey parts littering the floor (Richards *et al.* 2008). Foraging occurs in an area of approximately 60 ha, in a radius of approximately 2 km from the bats' roost (Tidemann *et al.* 1985).

**Likelihood of Occurrence**: High. Previous surveys completed by *ecologia* in 2001 and 2005 recorded a number of roost caves identified by Armstrong and Anstee (2000a) within and closeby to the the study area. The location and details of these caves are shown in Table 5.2 and mapped in Figure 5.2.

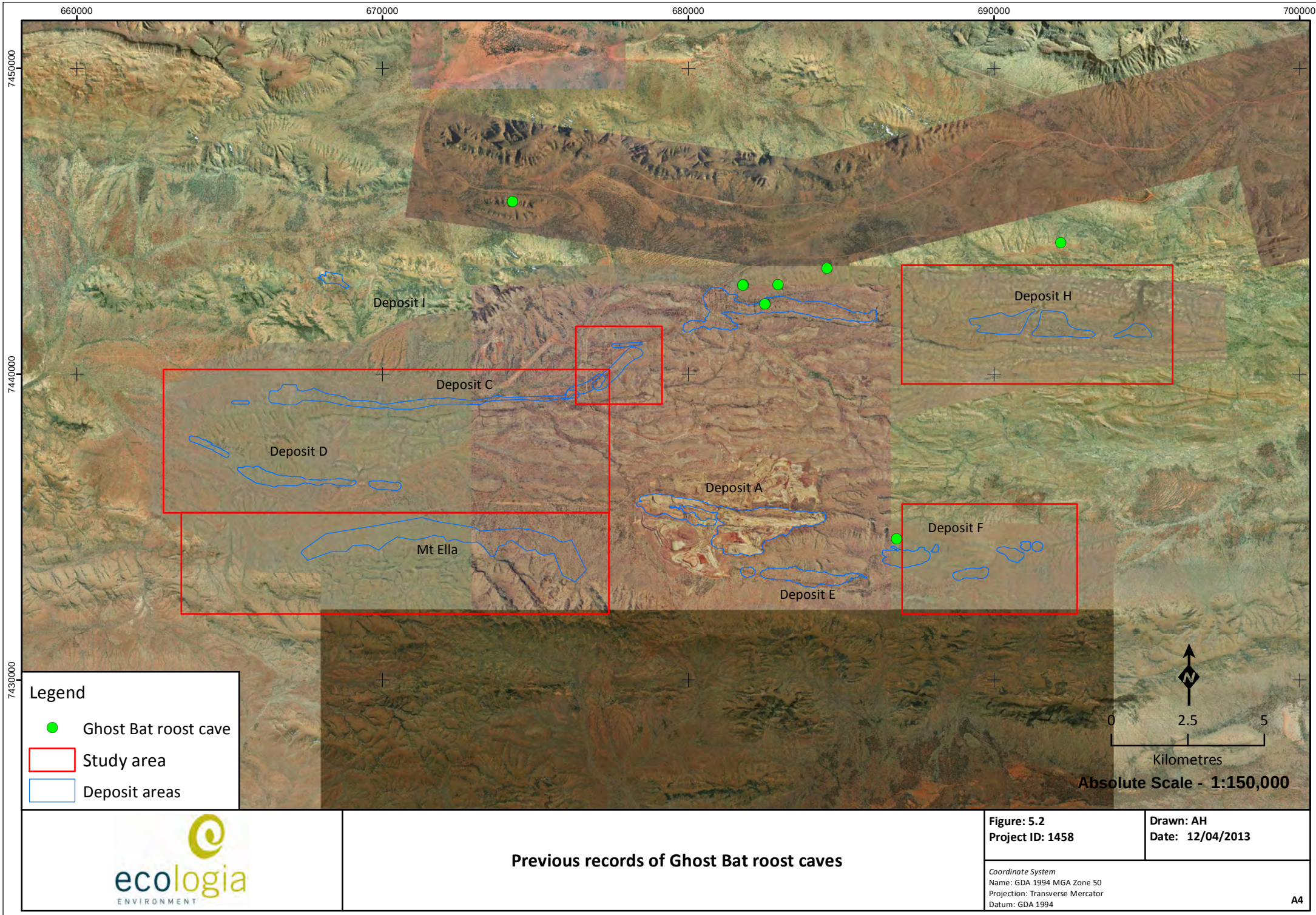
**Table 5.2 – Previous Ghost Bat records**

| Cave name | Easting | Northing | Details |
|---|---|---|---|
| AA1 | 686812 | 7434617 | Potential maternity cave (2001) |
| A1 | 681792 | 7442918 | Signs of recent use (2001) |
| I1 | 684534 | 7443453 | Signs of recent use (2001) |

| Cave name | Easting | Northing | Details |
|---|---|---|---|
| L2 | 682928 | 7442914 | Signs of recent use (2001) |
| L3 | 681780 | 7442910 | Signs of previous use but not recent (2001) |
| WA Adit | 682500 | 7442300 | Signs of previous use but not recent (2001) |
| AB1 | 674247 | 7445653 | Signs of recent use (2001) |
| Cave 1 | 692183 | 7444296 | Calls recorded close by but no evidence of activity (2005) |

Despite the location of eight roost caves previously identified within close proximity to the study area, this species was not recorded. However, in order to avoid disturbance, previously known roost caves were not investigated on this current survey, with detection techniques restricted to call echolocation recordings using SM2BAT units. Churchill (2008) notes the Ghost Bat does not exclusively hunt using echolocation calls, but also hunts by eyesight and passive listening. As a result, the minimal use of echolocation when hunting reduces the likelihood of this species being record via the SM2BAT units.

Potential new roost caves were searched for within major gorge and gully and hilltop, hillslope, ridge and cliff habitat types, with no caves recorded, however, not all areas of potential habitat were searched, therefore roost caves could be present within the study area. Despite not being recorded on this survey, due to the previous records of this species it should be considered as present within the study area.




ecologia ENVIRONMENT

**Previous records of Ghost Bat roost caves**

**Figure: 5.2**
**Project ID: 1458**

**Drawn: AH**
**Date: 12/04/2013**

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

**A4**

#### 5.3.1.4 Short-tailed Mouse (*Leggadina lakedownensis*)

**Conservation Status:** DEC Priority 4.

**Distribution and Habitat:** Populations of this small, secretive rodent are distributed across northern Australia, but records have been sporadic (Moro and Kutt 2008). They occupy a diverse range of habitats from the monsoon tropical coast to semiarid climates, including spinifex and tussock grasslands, samphire and sedgelands, acacia shrublands, tropical eucalypt and melaleuca woodlands and stony ranges. Most habitats, however, are seasonally inundated on red or white sandy-clay soils (Moro and Kutt 2008).

**Ecology:** The diet of the Short-tailed Mouse consists primarily of invertebrates, with plants supplementing their water requirements (Moro and Kutt 2008). Populations fluctuate greatly in response to rainfall, sometimes reaching plague proportions. The species is nocturnal and solitary, spending the day in simple, single-chambered burrows (Moro and Kutt 2008).

**Likelihood of Occurrence:** High. NatureMap lists three records from 1997 of which one record is located within the study area and the other two records are within 1 km of the study area (DPaW 2013). These specimens were lodged with WA Museum (M47672, M47673, M47777). The cracking clay habitat type represents ideal habitat for this species within the Pilbara region. The Short-tailed Mouse is regularly trapped using pitfall and Elliott traps, hence if a population was present within close proximity to site GWA S8 of at the time of surveying, it would be expected to record this species. The previous records of this species within the study area along with 2.42 $km^2$ of suitable habitat (cracking clay) suggest although not recorded on this survey, it is a high likelihood of occurrence.

#### 5.3.1.5 Western Pebble-mound Mouse (*Pseudomys chapmani*)

**Conservation Status:** DEC Priority 4.

**Distribution and Habitat:** The Western Pebble-mound Mouse occurs across central and southern Pilbara and extends into the smaller ranges of the Little Sandy Desert (Start 2008). Abandoned mounds have been found in the Gascoyne and Murchison, indicating a recent decline in distribution. This decline is most likely attributable to foxes and exotic herbivores (Start 2008). However, the species appears relatively secure in its remaining range (Start 2008). The Western Pebble-mound Mouse inhabits gently sloping hills of rocky ranges where the ground is stony and vegetated by spinifex with a sparse overstorey of eucalypts and scattered shrubs of senna, acacia and *Ptilotus* spp.

**Ecology:** In suitable habitats, pebble mounds of this species can be found in large numbers, although not all of these mounds are active and occupied by Pebble-mound Mice at the same time. The demographic structure of the groups that inhabit the mounds and their patterns of movement around the mounds is still unknown (Anstee 1996; Anstee *et al.* 1997). Mounds can cover an area of 0.5 to 9.0 $m^2$, and a single mound can house up to 25 mice (Start 2008). Breeding occurs throughout the year with females producing several litters of four young per year (Start 2008).

**Likelihood of Occurrence:** Recorded. A total of 30 active and inactive mounds were recorded from within the study area (Table 4.4, Figure 4.15). The species has been recorded frequently in the surrounding region and during 12 previous surveys (Ninox 1994; HGM 1999a, DEC 2013, ecologia internal database, Ninox 2009a, 2009b, Biota 2010; 1999b; Maunsell 2003). Although not directly trapped, the presence of numerous active mounds (Figure 5.3) for this species indicate the Western Pebble-mound Mouse is present within the study area



**Figure 5.3 – Active mound of Western Pebble-mound Mouse**

### 5.3.2 Birds

#### 5.3.2.1 Fork-tailed Swift (*Apus pacificus*)

**Conservation Status:** EPBC Act Migratory, WC Act Schedule 3.

**Distribution and Habitat:** The Fork-tailed Swift is a small, insectivorous species with a white throat and rump, and a deeply forked tail (Morcombe 2000). It is distributed from central Siberia and throughout Asia, breeding in north-east and mid-east Asia, and wintering in Australia and south New Guinea. It is a relatively common trans-equatorial migrant from October to April throughout mainland Australia (Simpson and Day 2004). In Western Australia the species begins to arrive in the Kimberley in late September, the Pilbara in November and the South-west by mid-December (Johnstone and Storr 1998). In Western Australia the Fork-tailed Swift is considered uncommon to moderately common near the north-west, west and south-east coasts, common in the Kimberley and rare or scarce elsewhere (Johnstone and Storr 1998).

**Ecology:** Fork-tailed Swifts are nomadic in response to broad-scale weather pattern changes. They are attracted to thunderstorms where they can be seen in flocks, occasionally of up to 2,000 birds. They rarely land, living almost exclusively in the air and feeding entirely on aerial insects, especially nuptial swarms of beetles, ants, termites and native bees (Simpson and Day 2004).

**Likelihood of Occurrence:** Recorded. Fork-tailed Swifts have previously been recorded in the region from the literature review and two databases (Appendix E). Seven separate observations were made of this species during the current assessment from five different locations (Table 4.4, Figure 4.15), totalling 553 records (Appendix F).

The large flock of 400 birds recorded from GWA S7 in conjunction with arriving thunderstorm cloud activity is of note, as this is a significant formation and consistent with the literature (Johnstone and Storr 1998). Following the arrival of this large flock, subsequent observations over the coming days consisted of smaller, looser flocks of birds foraging over the landscape. Although this species does not directly utilise habitats, observations were made of Fork-tailed Swifts flying at canopy level, activily hunting aerial insects following the rainfall on the proceeding days. The locations of these further observations were all in low lying habitats (mixed acacia woodland, footslope and plain) within the broad valley floor, suggesting although not directly utilising the habitats within the study area, landform features are still important for foraging activity of this species.

#### 5.3.2.2 Rainbow Bee-eater (*Merops ornatus*)

**Conservation Status:** EPBC Act Migratory, WC Act Schedule 3.

**Distribution and Habitat:** The Rainbow Bee-eater is scarce to common throughout much of Western Australia, except for the arid interior, preferring lightly wooded, preferably sandy country near water (Johnstone and Storr 1998).

**Ecology:** In Western Australia the Rainbow Bee-eater can occur as a resident, breeding visitor, post-nuptial nomad, passage migrant or winter visitor. It nests in burrows usually dug at a slight angle on flat ground, sandy banks or cuttings, and often at the margins of roads or tracks (Simpson and Day 2004). Eggs are laid at the end of the metre-long tunnel from August to January (Boland 2004). Rainbow Bee-eaters are most susceptible to predation during breeding, as it spends significantly more time on the ground in this period.

**Likelihood of Occurrence:** High. In total, 16 previous surveys resulted in the observation of this species within 50 km of the study area (Ninox 1994; HGM 1999a, ecologia internal database, Biota 2010; 1999b; Maunsell 2003). Despite the lack of records of this species during this survey, the species has a high likelihood of occuring within the study area. Suitable foraging and nesting habitat is found within the major drainage system habitat type.

#### 5.3.2.3 Peregrine Falcon (*Falco peregrinus*)

**Conservation Status:** WC Act Schedule 4 (Specially Protected Fauna).

**Distribution and Habitat:** This nomadic or sedentary falcon is widespread in many parts of Australia and some of its continental islands, but absent from most deserts and the Nullarbor Plain. The species is considered to be moderately common in the Stirling Range, uncommon in the Kimberley, Hamersley and Darling Ranges, and rare or scarce elsewhere (Johnstone and Storr 1998). The Peregrine Falcon occurs most commonly near cliffs along coasts, rivers and ranges, and around wooded watercourses and lakes.

**Ecology:** Peregrine Falcons feed almost entirely on birds, especially parrots and pigeons. They nest primarily on ledges on cliffs, granite outcrops and in quarries, but may also nest in tree hollows around wetlands. Eggs are predominantly laid in September (Johnstone and Storr 1998; Olsen *et al.* 2006).

**Likelihood of Occurrence:** Medium. The Peregrine Falcon has been recorded during two previous surveys within 50 km of the study area (ecologia internal database, Ninox 1994). Three additional records are listed on NatureMap within 100 km (DPaW 2013). Suitable habitat for hunting is present within the study area in the form of all fauna habitat types, with potential nest site habitat present along vertical cliff edges within the hilltop, hillslope, ridge and cliff habitat type.

#### 5.3.2.4 Grey Falcon (*Falco hypoleucos*)

**Conservation Status:** WC Act Schedule 1 (Vulnerable)

**Distribution and Habitat:** Grey Falcons are a rare, nomadic species sparsely distributed across much of arid and semi-arid Australia. In Western Australia, they are restricted to the northern half, occurring in a variety of habitats ranging from wooded drainage systems through to open spinifex plains. Grey Falcons once occurred across much of Western Australia, with sightings as far south as York and New Norcia during colonial times. However, the current distribution is now thought to be restricted to north of 26 °S (Johnstone and Storr 1998). Because the distribution of this species is scarce over an extremely large area, sightings of this species are very uncommon.

The Grey Falcon occurs in a wide variety of arid habitats, including open woodlands and open acacia shrubland, hummock and tussock grasslands and low shrublands, and may also be seen around swamps and waterholes that attract prey (Ehmann and Watson 2008).

**Ecology:** Like other falcons, this species preys primarily on birds such as parrots and pigeons, although reptiles and mammals are also taken (Ehmann and Watson 2008). Two to three eggs are laid in winter in the nests of other birds of prey and ravens, typically in tall eucalypt trees near water (Garnett and Crowley 2000; Ehmann and Watson 2008).

**Likelihood of Occurrence:** Medium. The Grey Falcon has been previously recorded relatively close by (*ecologia* internal database) and four recent records were identified from within 16 km (DPaW 2013) (Figure 4.14). Suitable habitat for hunting is present within the study area in the form of all fauna habitat types, however the Grey Falcon is unlikely to nest in any natural habitats present within the study area. Conversely man-made structures such as radio and communication towers are commonly used by Grey Falcons in the Pilbara.

#### 5.3.2.5 Australian Bustard (*Ardeotis australis*)

**Conservation Status:** DEC Priority 4.

**Distribution and Habitat:** The Australian Bustard occurs Australia-wide and utilises a number of open habitats, including open or lightly wooded grasslands, chenopod flats, plains and heathlands (Johnstone and Storr 1998).

**Ecology:** It is a nomadic species, ranging over very large areas, and its abundance varies locally and seasonally from scarce to common, largely dependent on rainfall and food availability. The Australian Bustard has an omnivorous diet, feeding on grasses, seeds, fruit, insects and small vertebrates.

Although the population size is still substantial, there has been a large historical decline in abundance, particularly south of the tropics, but also across northern Australia (Garnett and Crowley 2000). This is a result of hunting, degradation of its grassland habitat by sheep and rabbits, and predation by foxes and cats (Frith 1976; Garnett and Crowley 2000). Australian Bustards readily desert nests in response to disturbance by humans, sheep or cattle (Garnett and Crowley 2000).

**Likelihood of Occurrence:** Recorded. Three individual Australian Bustards were recorded from three separate locations during this survey. This species has also been recorded during seven previous surveys within 50 km of the study area (Ninox 1994, 1995; HGM 1999a, 2009a, 2009b, ecologia internal database; 1999b) in addition to eight NatureMap records within 45 km of the study area (DPaW 2013). The Australian Bustard is likely to occur on any of the low lying habitats within the study area, such as cracking clay, footslope and plain and mixed acacia woodland.

#### 5.3.2.6 Bush Stone-curlew (*Burhinus grallarius*)

**Conservation Status:** DEC Priority 4.

**Distribution and Habitat:** The Bush Stone-curlew occurs across much of Australia, except the arid interior and central south coast, preferring lightly wooded country near thickets or long grass that acts as daytime shelter (Johnstone and Storr 1998). Historically, this species was widely distributed throughout most of WA, but has since declined, particularly in the southern part of the State. Recent estimates indicate an Australian population of 15,000 individuals (Garnett and Crowley 2000). The Bush Stone-curlew inhabits woodlands, dry and open grasslands, and croplands with cover nearby (NSW National Parks and Wildlife Service 1999).

**Ecology:** The species is insectivorous, preying primarily upon beetles, although they will also eat seeds and shoots, frogs, lizards and snakes (Marchant and Higgins 1993; NSW National Parks and Wildlife Service 1999). They are usually seen in pairs, although may occasionally flock together during the breeding season (August to January) and are generally nocturnal, being especially active on moonlit nights (NSW National Parks and Wildlife Service 1999).

Since Bush Stone-curlews are a ground-dwelling and non-migratory species, they are quite susceptible to local disturbances by humans and to predation by cats and foxes (Frith 1976; Johnstone and Storr 1998). They are most common where land disturbance is minimal, and generally become rare or extinct around human settlements (Johnstone and Storr 1998).

**Likelihood of Occurrence:** Recorded. This species was recorded from secondary evidence only, with tracks recorded from GWA S3, which represents suitable habitat for this species (mulga woodland). In the local region, three additional records exist within 50 km of the study area (DEC 2013). This species is likely to occur in low lying habitat areas within micro-habitats of denser grass and shrub vegetation which provides cover for this species to shelter in during the day.

### 5.3.3 Reptiles

#### 5.3.3.1 Pilbara Olive Python (*Liasis olivaceus barroni*)

**Conservation Status:** EPBC Act Vulnerable, WC Act Schedule 1 (Vulnerable).

**Distribution and Habitat:** The Pilbara subspecies of the Olive Python only occurs in the ranges of the Pilbara region of Western Australia. It inhabits watercourses and areas of permanent water in rocky gorges and gullies (Pearson 2006).

**Ecology:** This subspecies is an adept swimmer, often hunting in water, feeding on a variety of vertebrates such as rock wallabies, fruit bats, ducks and pigeons. Individuals spend the cooler winter months sheltering in caves and rock crevices. In the warmer months the pythons can move widely, usually in close proximity to water and rock outcrops (DEWHA 2008a). In late winter or early spring males will travel large distances to find, and mate with, females.

Population size estimates are difficult due to the Olive Python's cryptic nature and lack of reliable trapping or census techniques (DEWHA 2008a). The main threats to this subspecies come from predation by feral cats and foxes, particularly of juveniles, competition with foxes for food, and destruction of habitat (Pearson 2006).

**Likelihood of Occurrence**: High. Eight records of the Pilbara Olive Python exist within 50 km of the study area (ecologia internal database,HGM 1999b; Maunsell 2003), with the closest being just 1 km to the north-east of the study area (DPaW 2013) (Figure 4.14).

Habitat assessed as critical habitat where the Pilbara Olive Python is likely to exist within the study area, is in the form of the major gorge and gully habitat type. Individuals are likely to remain in this

habitat for extended periods of time, however males are known to travel long distances during the breeding season and could occur in any habitat type while moving between more typical habitat.

#### 5.3.3.2 *Ramphotyphlops ganei*

**Conservation Status:** DEC Priority 1.

**Distribution and Habitat:** Very little is known about this elusive blind snake due to its fossorial lifestyle. Blind snakes are exclusively insectivorous, and like other members of their genus, *R. ganei* probably burrow into social insect colonies to feed on termites and ants, as well as their eggs and pupae (Wilson and Swan 2010). *R. ganei* has been found within the Pilbara region between Newman and Pannawonica (Wilson and Swan 2010).

**Ecology:** It has been suggested that *R. ganei* prefer to live in subterranean habitats near moist gullies and gorges (Wilson and Swan 2010), although there is a record from sandy soil vegetated with spinifex (NatureMap). This species is most likely threatened by removal of suitable habitat, and by drilling and/or any other mining activities impacting the subterranean environment.

**Likelihood of Occurrence:** Medium. This blindsnake has been recorded from eleven locations within 100 km of the study area (DEC 2013). The local previous surveys failed to record this species within 50 km (Appendix E). However, due to the elusive nature of this species, detecting presence remains difficult, despite the species potentially being present.

#### 5.3.3.3 Pilbara Barking Gecko (*Underwoodisaurus seorsus*)

**Conservation Status:** DEC Priority 1.

**Distribution and Habitat:** This gecko is found only on ridge tops and in rocky gorges of the Hamersley Range and is currently known from four locations (Wilson and Swan 2010, DEC 2013; Doughty and Oliver 2011a).

**Ecology:** Little is known of the Pilbara Barking Geckos ecology, but it is presumably similar to other *Underwoodisaurus* and *Nephrurus* species, which are nocturnal ground dwellers that feed mostly on insects and smaller geckos (Wilson and Swan 2010).

**Likelihood of Occurrence:** Recorded. One individual Pilbara Barking Gecko was recorded during this survey from site GWA S1 during phase 2. The habitat of this location record is consistent with that in the recent description of this species (Doughty and Oliver 2011b). The species' type locality lies within 20 km of the study area and therefore the study area is likely to harbour a local population. Suitable habitat is present in the form of major gorge and gully, mesa top and hilltop, hillslope, cliff and ridge habitat types.

## 5.4 INVERTEBRATE SHORT RANGE ENDEMIC FAUNA

### 5.4.1 Mygalomorphae (trap door spiders)

Mygalomorphae are burrowing spiders, often displaying low dispersal abilities, low fecundity and high life expectancy (Main 1985; Main 1992). The order represents one of the primary target groups in surveys of short range endemic taxa (Harvey 2002) and contains several species of conservation significance, such as the EPBC Act listed *Idiosoma nigrum* Main, 1952 (Approved Conservation Advice for *Idiosoma nigrum* (shield-back spider), 2013), or the WC Act listed *Kwonkan eboracum Main,* 1983 and *Moggridgea tingle* (Western Australian Government 2012). The Western Australian mygalomorph fauna is vast and, taxonomically, many families and genera remain known poorly (e.g. Barychelidae: *Idiommata;* Idiopidae: *Aganippe;* Nemesiidae: *Aname, Chenistonia, Kwonkan).*

#### 5.4.1.1 Family Barychelidae

**Species: *Aurecocrypta* sp. indet.**

*Aurecocrypta* sp. indet. was recorded from this survey from a single juvenile individual, captured opportunistically from GWA S11 (Table 4.5, Figure 4.16). Due to the life stage of this individual being juvenile, this specimen was unable to be identified to full species level. The record location is outside any deposit areas, recorded within the footslope and plain habitat type, which is the most extensive habitat type within the study area (Table 4.1, Figure 4.1). This species is a potential SRE (Beavis *et al.* 2013).

**Species: *Synothele* 'MYG127'**

A single adult male individual of this species was recorded from site GWA S7, captured within a dry pitfall trap (Table 4.5). This species is widespread and thus not considered an SRE (Beavis *et al.* 2013).

#### 5.4.1.2 Family Nemesiidae

**Species: *Aname mellosa***

A total of two male adults were recorded from site GWA S10, both captured within dry pitfall traps (Table 4.5). This species is widespread and thus not considered an SRE (Beavis *et al.* 2013).

**Species: *Yilgarnia* 'MYG197'**

A single male individual of this species was recorded from site GWA S7 within a dry pitfall trap (Table 4.5, Figure 4.16). The location of this site is within Deposit D in the footslopes and plain habitat type (Figure 4.1). It was not recorded at any other site outside the deposit area. This species has previously been recorded, and identified as a potential SRE species during the literature review (Appendix E). WAM have noted that this group is poorly represented in the collection, with only two specimens submitted. This species is considered a potential SRE (Beavis *et al.* 2013).

### 5.4.2 Scorpiones (scorpions)

Scorpiones is a relatively small order of arachnids, with approximately 1,700 described species (Fet *et al.* 2000). Scorpions are instantly recognisable by the presence of chelate pedipalps, pectenes and an elongate metasoma with a terminal sting. Scorpions are infamous for their venomous sting, which they use to subdue prey and for defence. In most species, the venom is relatively benign for humans, resulting in varying degrees of discomfort. The venom from 25 species only (all members of the family Buthidae) is known to be fatal to humans (Fet *et al.* 2000). Scorpions are important predators and, in some ecosystems, their diversity and abundance contribute significantly to the biomass of animal assemblages (Polis 1993).

#### 5.4.2.1 Family Buthidae

**Species: *Lychas* 'harveyi'**

*Lychas* 'harveyi' is a well-defined and clearly recognised morphospecies. A total of eight individuals from six different sites were recorded (Table 4.5). Records are known from the Midwest and Pilbara regions of Western Australia where it is one of the most common scorpion species, and is therefore relatively widespread. *Lychas* 'harveyi' is not considered an SRE (Volschenk and Framenau 2013).

**Species: *Lychas* 'pilbara1'**

*Lychas* 'pilbara1' is a well-defined and clearly recognised morphospecies. *Lychas* 'pilbara1' has been recorded throughout the Pilbara region of Western Australia. During this survey, a total of 17 individuals from five separate sites were recorded (Table 4.5). Despite the widespread distribution, this species has a very patchy distribution and has not been recorded as common. *Lychas* 'pilbara1' is not considered an SRE (Volschenk and Framenau 2013).

**Species: *Lychas bituberculatus***

Two *Lychas bituberculatus* individuals were recorded from site GWA S7 (Table 4.5). The species is widespread in the Pilbara and Kimberley regions of Western Australia. It is not considered an SRE (Volschenk and Framenau 2013).

**Species: *Lychas* 'hairy tail'**

*Lychas* 'hairy tail' is a well-recognised morphospecies. This survey recorded a single male individual from a dry pitfall trap from site GWA S2 (Table 4.5). Regional records are known from the Midwest and Pilbara regions of Western Australia where it is one of the most common scorpion species. It is not considered an SRE (Volschenk and Framenau 2013).

**Species: *Isometroides* 'pilbara1'**

*Isometriodes* 'pilbara 1' is a well-recognised morphospecies. A single male individual was recorded from site GWA S8 (Table 4.5). It is widespread throughout the Pilbara region of Western Australia. It is not considered an SRE (Volschenk and Framenau 2013).

#### 5.4.2.2 Family Urodacidae

The family Urodacidae is endemic to Australia (Fet *et al.* 2000; Volschenk *et al.* 2000; Prendini and Wheeler 2005) where it is represented by the genera *Urodacus* and *Aops*.

**Genus *Urodacus***

*Urodacus* was considered a member of the family Scorpionoidea for many years, but in a revision of the superfamily Scorpionoidea, Prendini (2000) placed *Urodacus* in its own family, Urodacidae. Unlike the species designations for Buthidae, Koch's (1977) species of *Urodacus* have been mostly supported by subsequent authors (Volschenk *et al.* 2000; Harvey and Volschenk 2002; Volschenk and Prendini 2008). The biggest issue confronting *Urodacus* taxonomy is the number of undescribed species being uncovered through current revisionary work (E. S. Volschenk unpublished data). Currently, 23 species of *Urodacus* are described; however, this may represent as little as 20% of the real diversity of this genus in Australia. *Urodacus* appears to be most diverse in Western Australia and few species are recorded east of the Great Dividing Range in eastern Australia. *Urodacus* contains both widespread and SRE species. During a large-scale survey of the Pilbara fauna, Volschenk *et al.* (2000) recorded nine undescribed species and only one formerly described species was reported in that study.

***Species: Urodacus* sp. indet**

A total of 10 unidentifiable females and juveniles of *Urodacus* were collected from a number of locations (Table 4.5). No adult male specimens were collected and therefore this species is unable to be morphologically identified to species level. Specimens have been preserved appropriately to allow for DNA analysis to species level if required. The individuals recorded are spread across much of the study area, both within deposit areas and outside, and in a variety of habitats (Figure 4.16). All records were made from low lying habitat types and within micro-habitats of softer soil substrates, where this species constructs burrows to shelter in during the day. All specimens recorded were caught through targeted pitfall trapping using plastic cups placed at the base of burrows. An example of a burrow from this species is shown in Figure 5.4.

Unidentifiable individuals have previously been recorded in the region and were assessed as potential SRE (Appendix E). As *Urodacus* includes range-restricted in addition to widespread species, all unidentified specimens are here considered potential SREs (Volschenk and Framenau 2013).



**Figure 5.4 – Example of burrow of *Urodacus* sp. indet. recorded from current survey**

### 5.4.3 Isopoda (isopods)

#### 5.4.3.1 Family Armadillidae

**Species: *Buddelundia* sp. nov. '10'**

This is a species complex and is common and widespread in the Pilbara. There were at least four morphologically different forms found in this survey (*Buddelundia* sp. nov. 10 1458A – 1458D). Further work on this group of species is required to understand better their true SRE status. Morphological characteristics used in identification are subtle, with DNA analysis recommended for full resolution of species present. The four morphs recorded from this survey are described below, all of which are considered to be potential SREs (Judd 2012).

***Buddelundia* sp. nov. '10 1458A'**

This species was the most abundant recorded from the survey, with a total of 70 individuals recorded from 10 locations (Table 4.5). These locations range across various habitat types and are within and outside deposit areas (Figure 4.16).

***Buddelundia* sp. nov. '10 1458B'**

A total of nine individuals (five male, four female) were recorded from four separate locations from this study (Table 4.5). This form is relatively distinct from 1458A (Judd 2012).

***Buddelundia* sp. nov. '10 1458C'**

This species was represented by a single female specimen, recorded from a dry pitfall trap at site GWA S1 (Table 4.5). The location for this record is within the mesa top habitat type, with the single location record meaning this species was recorded from within deposit H only (Figure 4.16).

This species is very similar morphologically to *Buddelundia* sp. nov. '10 1458A' and was recorded from the same site. Further surveying for this species, including male specimens, is needed to provide a more definitive determination of species present (Judd 2012).

***Buddelundia* sp. nov. '10 1458D'**

A total of four individuals (three male, one female) of this species were recorded from site GWA S2 only (Table 4.5). The location for this record is within the mesa top habitat type, with the single location record meaning this species was recorded from within deposit H only (Figure 4.16).

Morphologically, this species appears to be much smaller to aid in distinguishing them from the more commonly recorded to *Buddelundia* sp. nov. '10 1458A'. Further surveying for this species is needed to provide a more definitive determination of species present (Judd 2012).

**Species: *Buddelundia* sp. nov. '15'**

This species had a total of three individuals from three separate sites recorded (Table 4.5). This species is a widespread species complex in the Pilbara. Further work is needed on the species complex, however at present this is not considered an SRE species (Judd 2012).

**Species: *Buddelundia* sp. nov. '16'**

A total of 14 individuals of this species were recorded from five locations (Table 4.5). This species is a widespread species complex in the Pilbara. Further work is needed on the species complex, however at present this is not considered an SRE species (Judd and Framenau 2013).

**Species: *Buddelundia* sp. nov. '68WA'**

Two individuals (one male, one female) of this species were recorded from two locations (GWA S5, FS1) (Table 4.5). Both locations fall within potential impact areas of deposit G and Mt Ella, both located within the footslope and plain habitat type (Figure 4.16).

*Buddelundia* sp. nov. '68WA' is a large and distinctive species that is part of a specialized group of *Buddelundia*. The specimens identified on this survey are very similar to (or the same species as) a confirmed SRE species (*Buddelundia* sp. nov. 68) (Judd 2012), however enough morphological traits exist to determine them as separate species at this stage. There are many species very similar to these specimens with the majority being SRE species. As a result, *Buddelundia* sp. nov. '68WA' is considered a potential SRE species (Judd 2012).

**Species: Buddelundinae genus. indet. Buddelundinae 'PES999'**

A total of six individuals of *Buddelundinae* 'PES999' were recorded (Table 4.5). This species belongs to an undescribed genus with close morphological affinities to *Buddelundia* spp. It is a widespread species in the Pilbara region and not considered an SRE (Judd and Framenau 2013).

**Species: New genus (close to *Buddelundia*) sp. nov. '1'**

A total of four individuals of this species were recorded (Table 4.5). This is a new genus which is closely related to *Buddelundia* but is thought to be more primitive. The species within this genus lack many of the morphological characteristics that are useful in determining species of *Buddelundia* spp.

Consequently, they are harder to identify. However, this species appears relatively widely distributed in the Pilbara region and is not considered an SRE (Judd 2012).

#### 5.4.3.2 Family Unknown

**Species: Genus indet. sp. indet.**

A single male specimen (*ecologia* database reference number EE12:0260) in poor condition, was recorded from site GWA S5 (Table 4.5). This single record was from within Mt Ella deposit within the footslope and plain habitat type (Figure 4.16).

This specimen was in poor condition when submitted for identification, making identification through morphology difficult. Unfortunately, both antenna, which are an important diagnostic characteristic in determining families of terrestrial isopods, were missing. Despite this, the individual appeared to be morphologically unique and unlike other isopods previously recorded from the Pilbara (Judd 2012). This specimen could potentially belong to the family Philosciidae or may be an introduced species, although this is unlikely (Judd 2012).

Complete specimens in better condition are required before a more accurate assessment as to the SRE status of this species, however this species should be considered a potential SRE at present (Judd 2012).

### 5.4.4 Molluscs (snails)

#### 5.4.4.1 Family Bothriembryontidae

Bothriembryontidae is a family of air-breathing land snails in the superfamily Orthalicoidea. The family has Gondwanaland distribution and comprises 12 genera. The genus *Bothriembryon* is endemic to Australia and includes over 40 described species.

**Species: *Bothriembryon* sp. nov. 'Pilbara'**

A total of four individuals from site GWA FS4 were recorded from this survey (Table 4.5). This species is currently undescribed but previous records suggest that this species is widespread throughout the Pilbara region and not considered an SRE species (Whisson 2013).

#### 5.4.4.2 Family Pupillidae

Pupillidae is a family of mostly minute, air-breathing land snails in the superfamily Pupilloidea. The family comprises 12 genera and harbours both widespread and range-restricted species.

**Species: *Gastrocopta mussoni***

This species had 12 individuals recorded from two locations (Table 4.5). Previous records show this species to be widespread and is therefore not considered an SRE (Whisson 2013).

**Species: *Gastrocopta cf. hedleyi***

A total of 12 individuals of this species were recorded from a single location only (Table 4.5). This species is likely to be conspecific with *Gastrocopta hedleyi,* which is a widespread species. This species is not considered a SRE species (Whisson 2013).

**Sub-family Pupillinae**

**Species: *Pupoides cf. pacificus***

This species had 11 individuals recorded from three locations (Table 4.5). It is most likely conspecific with *Pupoides pacificus,* which is a widespread species. This species is not considered an SRE species (Whisson 2013).

#### 5.4.4.3 Family Subulinidae

**Species: *Eremopeas interioris***

A total of 15 individuals of this species were recorded from two locations (Table 4.5). Current information suggests this species is widespread and is not considered an SRE species (Whisson 2013).

### 5.4.5 Pseudoscorpiones (Pseudoscorpions)

The Western Australian pseudoscorpion fauna is fairly diverse with representatives of 17 different families. They are found in a variety of biotopes, but can be most commonly collected from the bark of trees, from the underside of rocks, or from leaf litter habitats (Burger *et al.* 2013).

#### 5.4.5.1 Family Olpiidae

**Species *Beierolpium* sp. indet.**

A single juvenile from the genus *Beierolpium* was collected from site GWA S1 (Table 4.5). This means this species was recorded from within deposit H only, within the mesa top habitat type (Figure 4.1). Due to the juvenile life form of this individual, it cannot be identified to species level. A full taxonomic revision of the genus *Beierolpium* in Western Australia is necessary to confirm the specimen's species identity and distribution. At this stage this specimen is designated as a potential SRE due to taxonomic uncertainty (Burger *et al.* 2013).

**Species: *Euryolpium* sp. indet.**

A single juvenile from the genus *Euryolpium* was collected from site GWA S3 (Table 4.5), outside any deposit areas within the mulga woodland habitat type (Figure 4.1). Due to the juvenile life form of this individual, it cannot be identified to species level.

Species of *Euryolpium* are commonly found under bark and under rocks throughout Australia. They can be locally abundant, and at least one species is quite widespread across northern Australia (Burger *et al.* 2013). At this stage this specimen is designated as a potential SRE due to taxonomic uncertainty (Burger *et al.* 2013).

**Species: *Indolpium* sp. indet.**

A single male from the genus *Indolpium* was collected during the survey from site GWA S11 (Table 4.5). Similar specimens have been collected from other regions of Western Australia, however more data is required before the morpho-group can be accurately given species identifications (Burger *et al.* 2013)..

Based on current levels of knowledge from abundance and frequency of collection of specimens from this genus, it is unlikely that these specimens represent SREs. Therefore this species is currently not considered an SRE (Burger *et al.* 2013).

**Species: *Xenolpium* sp. indet.**

A total of 10 individuals (five male, four female, and one juvenile) of this species were recorded from seven separate locations (Table 4.5). These locations are from within and outside deposit areas and across different habitat types (Figure 4.1).

The specimens collected appear to represent a single species. Species of this genus need further taxonomic investigation to determine their SRE status. At present this species is considered a potential SRE (Burger *et al.* 2013).

**Species: Genus indet. sp. indet.**

Three juvenile olpiid pseudoscorpions from three separate sites (GWA opp, S1, S6, Table 4.5) could not be identified to genus level because of juvenile life stages. These locations are all from within deposit areas (Figure 4.1).

Due to the taxonomic uncertainty within olpiid pseudoscorpions, this species has been assigned potential SRE status. (Burger *et al.* 2013).

### 5.4.6 Diplopoda (millipedes and centipedes)

#### 5.4.6.1 Family Trigoniulidae

**Species: *Austrostrophus stictopygus***

*Austrostrophus* is the only genus of spirobolid millipede collected to date in the Pilbara. It is easily recognized by its large size, the punctations on the last body segment and a fringe of projections found on the trailing edge of each body segment (Hoffman 2003). There are two species of the genus found in Western Australia: *Austrostrophus* `DIP018` and *A. stictopygus*. They are very similar in appearance and can only be distinguished from each other by the structure of the male gonopods, which need to be dissected out to be examined.

A total of nine individuals (three male, three female and three juvenile, Table 4.5) were collected during this survey. Due to the abundant and widespread distribution of this species, it is not considered an SRE (Burger *et al.* 2013).

#### 5.4.6.2 Family Geophilidae

**Species: Genus ident. sp. indet**

A single individual of a centipede from the family Geophilidae was recorded from site GWA S2 (Table 4.5). This single location is within deposit H and the mesa top habitat type (Figure 4.1). The specimen was recorded by opportunistic foraging, and was recorded at the same location as the centipede from family Chilenophilidae. The microhabitat for the species was within a small rocky gully, underneath dense leaf litter and woody/rocky debris.

The current taxonomy of Geophilidae centipedes is limited, hence identification to genus and species level is not possible (Beavis *et al.* 2013). The literature review revealed genus ident. sp. indet specimens from the family Geophilidae have previously been recorded from the region (Appendix E) Due to taxonomic uncertainties, this species is considered a potential SRE (Beavis *et al.* 2013).

#### 5.4.6.3 Family Chilenophilidae

**Species: Genus ident. sp. indet**

As with the Geophilidae centipede discussed above, a single individual of a centipede from the family Chilenophilidae was recorded from site GWA S2 (Table 4.5). The single location is within deposit H and the mesa top habitat type (Figure 4.1). The microhabitat for the species was within a small rocky gully, underneath dense leaf litter and woody/rocky debris.

The current taxonomy of Chilenophilidae centipedes is limited, hence identification to genus and species level is not possible (Beavis *et al.* 2013). Due to taxonomic uncertainties, this species is considered a potential SRE (Beavis *et al.* 2013).

## 5.5 IMPACT ASSESSMENT

Due to that fact that this study for the Greater West Angelas Project is not for any specific development or mining project at present, identifying specific and direct impacts to fauna is not possible. If deposits are selected in the future to be further developed, the results from this study can be consulted as preliminary data to determine specific impacts, with further surveying of specific deposits recommended to gain a better understanding of potential impacts.

SRE fauna are particularly vulnerable to potential impacts due to their restricted distributions. Consequently, all SRE species recorded only within deposit areas should be searched for outside deposit areas to ensure particular species are not significantly impacted upon. Currently, nine potential SRE species are recorded from within deposit areas only; *Yilgarnia* 'MYG197', *Buddelundia* sp. nov. '10 1458C', *Buddelundia* sp. nov. '10 1458D', *Buddelundia* sp. nov. '68WA', isopod genus indet. sp. indet., *Beierolpium* sp. indet., pseudoscorpion genus indet. sp. indet., centipede (family Geophilidae) genus indet. sp. indet. and centipede (family Chilenophilidae) genus indet. sp. indet. (Table 4.5, Figure 4.1). Any future development will need to address the issue of distribution boundaries of each SRE species that was found within the impact areas.

There are no potential significant vertebrate fauna impacts likely for any vertebrate fauna species (including conservation significant species) at a regional level from the project. However, some local impacts to conservation significant species or endemic or bioregional species may occur.

Ghost Bats and Pilbara Leaf-nosed Bats are regarded as being shy of human presence and will abandon their roosts if disturbed. Any future developments should avoid any impacts to Ghost Bat (and Pilbara Leaf-nosed Bat if present) roost caves.

In general, vertebrate fauna species of high mobility should be able to move away from disturbance and avoid any significant impacts. Species that have low mobility or are burrowing species, are more susceptible to development impacts and may experience a local impact to individuals. Examples being the Western Pebble-mound Mouse as it shelters in burrow systems below ground during the day, and burowing species such as *Lerista* spp. skinks.

The skink *Ctenotus rutilans*, due to taxonomic uncertainty with this species (section 4.2.4), may be sensitive to impacts if undescribed species within this complex are present. Due to the apparent range extension to *Ctenotus robustus* (section 4.2.4) from this survey, an impact to this species would result in a range reduction. However, the scale of the Greater West Angelas Project is not considered large enough to result in any significant impact to either of these two skink species.

## 5.6 SURVEY ADEQUACY

Systematically obtained data (trapping results for terrestrial fauna and set-time survey for birds, excluding opportunistic data) was analysed for survey adequacy. Parametric analysis of systematically obtained survey data for birds and terrestrial faunal groups revealed that survey effort was adequate. Table 5.3 provides a summary of the theoretical maximum number of species using seven different methods of estimating richness. The Michaelis-Menten (MM) equation provides the most accurate representation of the potential species number. This is compared against the actual number of species observed, with any inconsistencies smoothed by an algorithm (Mao Tau), which simulates an infinite number of randomisations of the sample order.

Analysis of the mammal trapping data produced a reasonably smooth SAC, nearing the asymptotic plateau (Figure 5.5). Extrapolation of the Michaelis-Menten (MM) curve suggests that 96.1% of the theoretical total number of mammals able to be trapped had been captured at the completion of the 168 trap nights of the Level 2 vertebrate fauna survey (Table 5.3). These results indicate that the majority of mammal species were recorded during the survey.

Analysis of the reptiles trapping data produced a reasonably smooth SAC, almost reaching the asymptotic plateau (Figure 5.6). Extrapolation of the Michaelis-Menten (MM) curve suggests that 92.1% of the herpetofauna theoretically occurring in the study area were trapped. The MM estimator generated a theoretical maximum of 67 species, whilst other richness estimates were as high as 75.95 (Table 5.3), suggesting further survey effort could have identified as many as 10 more species.

The SAC analysis of the avifauna set-time survey dataset also produced a typical SAC, becoming very close to an asymptotic plateau (Figure 5.7). Used as a stopping rule, the MM estimator indicated that the survey was 98.5% adequate at the completion of 96 set-time surveys. The MM estimator generated a theoretical maximum of 72 species (71 species actually recorded), however other richness estimates were as high as 87 (Table 5.3), suggesting further survey effort could have recorded up to 16 additional species.

In contrast to vertebrate fauna groups, the SRE fauna SAC analysis shows a less rounded line, indicating that further sampling may have recorded additional species (Figure 5.8). Used as a stopping rule, the MM estimator indicated that the survey was 71.2% adequate. The MM estimator generated a theoretical maximum of 29.47 species (21 species actually recorded). Higher variations between total richness estimators for SRE fauna was recorded in contrast to vertebrate fauna groups, with estimators ranging from a low of 25.76 (Bootstrap) to 47.79 species (ACE) (Table 5.3), suggesting recording up to a further 26 species may be possible with further survey effort.

It is worth noting the SRE fauna SAC analysis uses systematic data collected from pitfall trapping data only, and does not include opportunistic methods such as leaf litter sorting and foraging which target specific SRE species groups.

**Table 5.3 – Mean estimates of total species richness of different fauna groups**

| Richness Estimators | Total Richness Estimate | | | |
|---|---|---|---|---|
| | Trappable mammals | Trappable reptiles | Birds | SRE |
| ACE | 10 | 68.31 | 77.88 | 47.79 |
| ICE | 10 | 68.09 | 81.09 | 45.47 |
| Chao-1 | 10 | 68.88 | 78 | 39.2 |
| Jack-1 | 10 | 72.93 | 82.88 | 32.9 |
| Jack-2 | 9.02 | 75.95 | 87.84 | 42.75 |
| Bootstrap | 10.14 | 67.62 | 76.46 | 25.76 |
| Michaelis-Menten | 10.41 | 67.3 | 72.16 | 29.47 |
| **Species trapped/observed** | **10** | **65** | **71** | **21** |

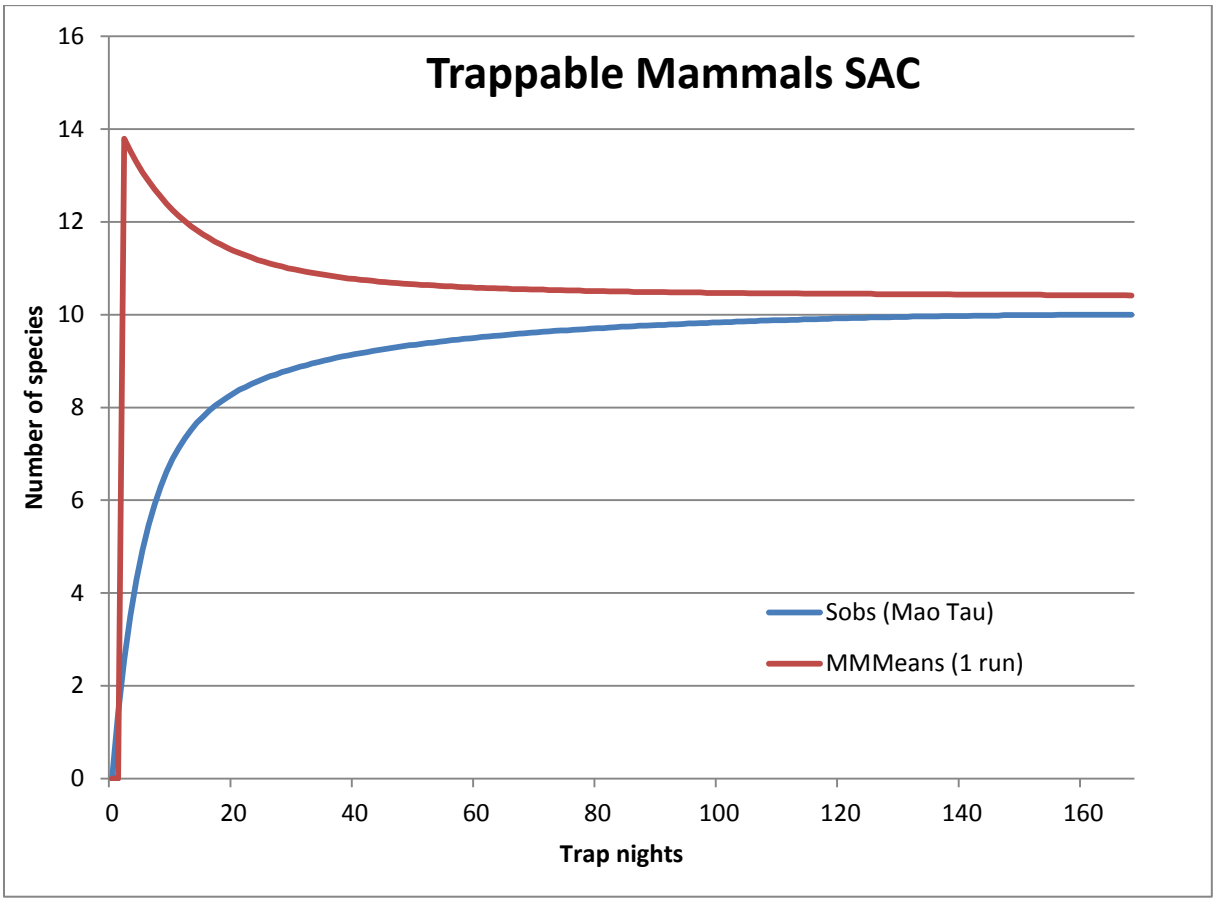



**Figure 5.5 – Species accumulation curve for trappable mammals**

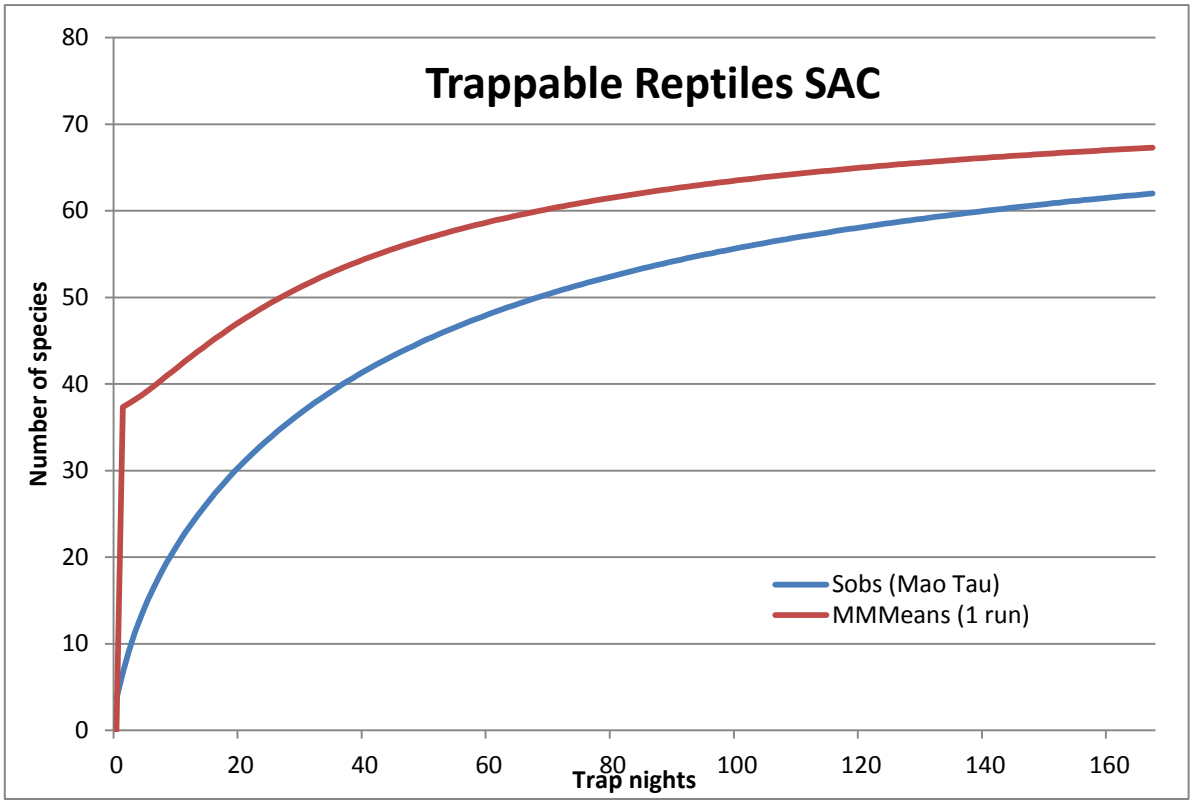



**Figure 5.6 – Species accumulation curve for trappable reptiles**

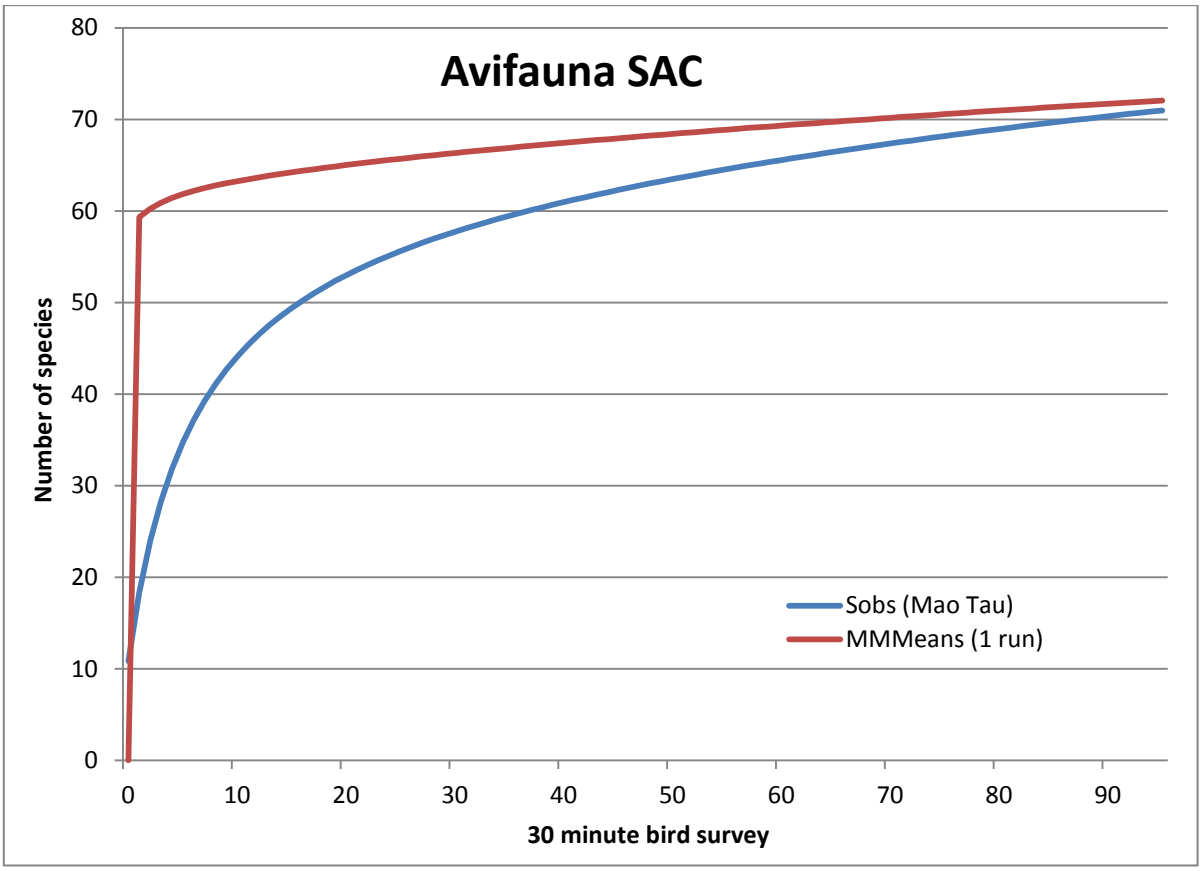



**Figure 5.7 – Species accumulation curve for avifauna**

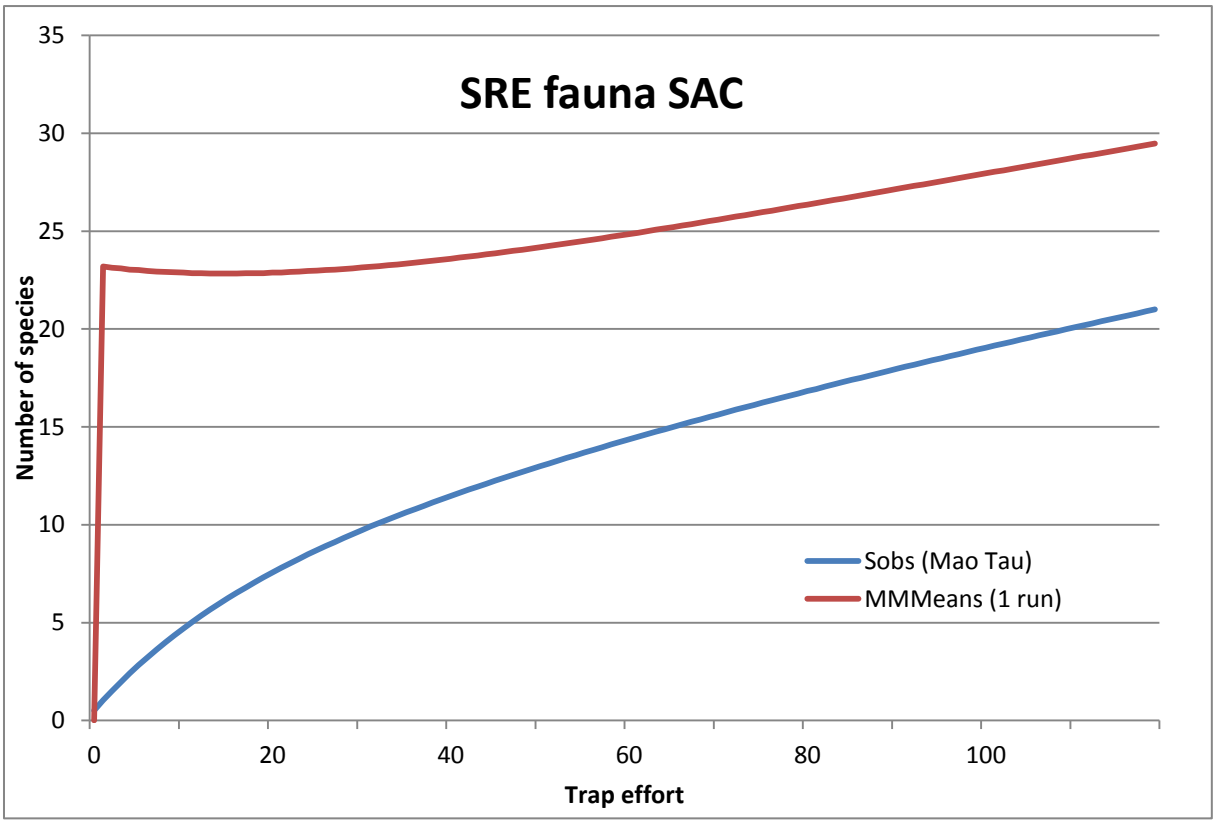



**Figure 5.8 – Species accumulation curve for SRE fauna**

## 5.7 SURVEY LIMITATIONS AND CONSTRAINTS

Limitations of the current survey are summarised in Table 5.4 below. No significant limitations were experienced during the surveys. Limited vehicle access to some habitat types (major gorge and gully, hilltop, hillslope, ridge and cliff) meant restricted systematic survey effort could be completed in these habitats type. Less represented habitats within the survey design of the systematic trap sites were compensated with opportunistic surveying. Given no significant limitations were encountered, the level of survey undertaken was considered adequate.

**Table 5.4 – Summary of survey limitations**

| Constraint | Relevant (yes/no) | Comment |
|---|---|---|
| Competency/experience of the consultant carrying out the survey. | No | All members of the survey team were experienced in Pilbara fauna identification and fauna surveys. |
| Scope (what faunal groups were sampled and were some sampling methods not able to be employed because of constraints such as weather conditions). | No | All faunal groups were adequately sampled. |
| Proportion of fauna identified, recorded and/or collected. | No | The majority of fauna species expected to occur within the study area were recorded, as indicated by SACs (Section 5.6). All captured vertebrate species were identified in the field. Invertebrate samples were identified by external specialists and lodged with WA Museum. |
| Sources of information (previously available information as distinct from new data). | No | Twenty-six biological surveys have been conducted in the vicinity of the study area. Data from these surveys were used included to provide regional context. |
| The proportion of the task achieved and further work which might be needed. | Partially | A two-phase Level 2 vertebrate and SRE fauna assessment was completed. The level of assessment for the Project is assessed as adequate. Additional SRE assessments may be required once detailed project design is developed |
| Timing/weather/season/cycle. | No | The Level 2 terrestrial fauna assessment was conducted during weather and seasonal conditions that are optimal for increased fauna activity and was in accordance with guidelines (EPA 2004). |
| Disturbances which affected results of the survey (e.g. fire, flood, accidental human intervention). | No | There were no disturbances recorded during this survey. |
| Intensity (in retrospect was the intensity adequate). | No | The survey intensity was adequate, all habitat types were surveyed systematically or opportunistically, and most of the species expected to occur were recorded. |
| Completeness (e.g. was relevant area fully surveyed). | No | All habitat types were accessible and were represented in the assessment. |
| Resources (e.g. degree of expertise available in animal identification to taxon level). | No | All zoologists were suitably qualified and experienced in identification of Pilbara fauna. There were no resources issues encountered. |
| Remoteness and/or access problems. | No | Sufficient contextual information was available on the Pilbara region and the study area. |
| Availability of contextual (e.g. biogeographic) information on the region). | No | Survey methods were suitable to record all fauna groups, including freshwater fish. |
| Efficacy of sampling methods (i.e. any groups not sampled by survey methods). | No | There were no disturbances and inefficiencies recorded during this survey. |

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# 6 CONCLUSION

The main conclusions from this study are as follows:

- A total of nine broad-scale habitat types have been assessed as existing within the study area; footslope or plain, hilltop, hillslope, ridge or cliff, mixed Acacia woodland, mesa top, cracking clay, major gorge and gully, major drainage, mulga woodland and cleared area. No habitats recorded are regarded as rare or unique to the study area.
- A total of 23 species of native mammals, two species of introduced mammal, 80 species of bird and 64 species of reptile were recorded during this survey. No species of amphibian were recorded.
- Six species of conservation significance (two mammal, three birds, one reptile) were recorded from within the study area; Pilbara Leaf-nosed Bat (Pilbara form) (EPBC VU, WC Act S1, DEC VU), Western Pebble-mound Mouse (signs only) (DEC P4), Fork-tailed Swift (EPBC M, WC Act S3), Australian Bustard (DEC P4), Bush Stone-curlew (signs only) (DEC P4) and Pilbara Barking Gecko (DEC P1).
- A total of 33 invertebrate species from six different Orders were submitted for identification and SRE status assessment. The results from identifications showed 15 of these species identified as potential SRE species; two species of spider, one species of scorpion, six species of isopods, four species of pseudoscorpions and two species of centipedes.
- Due to the fact that this study for the Greater West Angelas Project is not for any specific development or mining projects at present, identifying specific and direct impacts to fauna is not possible. If deposits are selected for further development in the future, further surveying of specific deposits is recommended to gain a better understanding of potential impacts. Currently, nine potential SRE species are recorded from within deposit areas only. There are no potential significant vertebrate fauna impacts likely for any vertebrate fauna species (including conservation significant species) at a regional level from the Project.
- Systematically obtained data was assessed to determine survey adequacy through SACs. Extrapolation of the Michaelis-Menten (MM) curve suggests that 96.1% of trappable mammals, 92.1% of trappable reptiles, 98.5% of avifauna and 71.2% of SRE fauna were recorded. This indicated that the majority of fauna were recorded for all fauna groups, however increased surveying is likely to record further species, particularly SREs.
- No significant limitations were experienced during the surveys. Given the lack of limitations and the fact that the majority of fauna were recorded, the survey can be considered adequate and to have met its objectives.

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# APPENDIX A EXPLANATION OF CONSERVATION CODES

**Appendix A1** Definitions of categories under the *Environment Protection and Biodiversity Conservation Act 1999*

| Category | Definition |
|---|---|
| Endangered (EN) | The species is likely to become extinct unless the circumstances and factors threatening its abundance, survival or evolutionary development cease to operate; or its numbers have been reduced to such a critical level, or its habitats have been so drastically reduced, that it is in immediate danger of extinction. |
| Vulnerable (VU) | Within the next 25 years, the species is likely to become endangered unless the circumstances and factors threatening its abundance, survival or evolutionary development cease to operate. |
| Migratory (M) | Species are defined as migratory if they are listed in an international agreement approved by the Commonwealth Environment Minister, including:<br>the Bonn Convention (Convention on the Conservation of Migratory Species of Wild Animal) for which Australia is a range state;<br>the agreement between the Government of Australian and the Government of the People's Republic of China for the Protection of Migratory Birds and their environment (CAMBA); or<br>the agreement between the Government of Japan and the Government of Australia for the Protection of Migratory Birds and Birds in Danger of Extinction and their Environment (JAMBA). |

**Appendix A2** Definition of Schedules under the *Wildlife Conservation Act 1950*

| Schedule | Definition |
|---|---|
| Schedule 1 (S1) | Fauna which are rare of likely to become extinct, are declared to be fauna that is in need of special protection. |
| Schedule 2 (S2) | Fauna which are presumed to be extinct, are declared to be fauna that is in need of species protection. |
| Schedule 3 (S3) | Birds which are subject to an agreement between the governments of Australia and Japan relating to the protection of migratory birds and birds in danger of extinction, are declared to be fauna that is in need of species protection. |
| Schedule 4 (S4) | Declared to be fauna that is in need of species protection, otherwise than for the reasons mentioned above. |

## **Appendix A3** Definition of DEC Threatened and Priority Fauna Codes

| **Threatened** | **Definition** |
|---|---|
| Critically Endangered (CR) | Considered to be facing an extremely high risk of extinction in the wild. |
| Endangered (EN) | Considered to be facing a very high risk of extinction in the wild. |
| Vulnerable (VU) | Considered to be facing a high risk of extinction in the wild. |
| **Priority** | **Definition** |
| Priority 1 (P1) | *Taxa with few, poorly known populations on threatened lands.*<br>Taxa which are known from few specimens or sight records from one or a few localities, on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, active mineral leases. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna. |
| Priority 2 (P2) | *Taxa with few, poorly known populations on conservation lands.*<br>Taxa which are known from few specimens or sight records from one or a few localities, on lands not under immediate threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant crown land, water reserves, etc. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna. |
| Priority 3 (P3) | *Taxa with several, poorly known populations, some on conservation lands.*<br>Taxa which are known from few specimens or sight records from several localities, some of which are on lands not under immediate threat of habitat destruction or degradation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna. |
| Priority 4 (P4) | *Taxa in need of monitoring.*<br>Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could if present circumstances change. These taxa are usually represented on conservation lands. |
| Priority 5 (P5) | *Taxa in need of monitoring.*<br>Taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years. |

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# APPENDIX B DAILY WEATHER DATA DURING SURVEY

| Date | Minimum Temperature (°C) | Maximum Temperature (°C) | Rainfall (mm) |
|---|---|---|---|
| **Phase 1** | | | |
| 25/9/12 | 13.8 | 32.0 | 0 |
| 26/9/12 | 11.4 | 32.4 | 0 |
| 27/9/12 | 16.4 | 29.4 | 0 |
| 28/9/12 | 16.3 | 28.2 | 0 |
| 29/9/12 | 15.9 | 34.2 | 0 |
| 30/9/12 | 15.4 | 35.6 | 0 |
| 1/10/12 | 20.2 | 36.5 | 0 |
| 2/10/12 | 21.2 | 35.9 | 0 |
| 3/10/12 | 17.0 | 34.7 | 0 |
| 4/10/12 | 16.0 | 37.7 | 0 |
| 5/10/12 | 17.0 | 38.1 | 0 |
| **Average** | **16.4** | **34.1** | **0** |
| **Phase 2** | | | |
| 18/03/13 | 26.0 | 42.8 | 0 |
| 19/03/13 | 24.9 | 43.1 | 0 |
| 20/03/13 | 28.8 | 42.3 | 0 |
| 21/03/13 | 31.4 | 40.9 | 0 |
| 22/03/13 | 23.2 | 41.7 | 0 |
| 23/03/13 | 25.3 | 41.2 | 0 |
| 24/03/13 | 23.8 | 40.6 | 0 |
| 25/03/13 | 21.9 | 41.1 | 0 |
| 26/03/13 | 20.8 | 31.1 | 0 |
| 27/03/13 | 18.7 | 31.7 | 0 |
| **Average** | **24.5** | **39.6** | **0** |

Note: Temperature data recorded from Paraburdoo weather station, rainfall data recorded from Turee Creek weather station (BoM 2013).

# APPENDIX C SITE DESCRIPTIONS

| Vegetation and Fauna Habitat Description | Site Photo |
|---|---|
| **GWA S1**<br>**Habitat type: Mesa top**<br>Open woodland within rocky hillslopes. Tree species consisting of *Acacia aneura*, *Eucalyptus leucophloia,* *Eucalyptus gamophylla* and *Acacia pruinocarpa*. Shrub species consisting of mixed *Acacia* spp. and *Gossypium robinsonii*. Grasses are dominated by *Triodia* sp. which occurs at medium density. Sparse wood and leaf litter exist with evidence of recent fire. Numerous rocky outcrops and continuous surface layer of small pebbles. |  |
| **GWA S2**<br>**Habitat type: Mesa top**<br>Very open woodland within rocky hillslopes. Tree species consisting of *Acacia aneura* and *Eucalyptus leucophloia*. Mixed shrub species of *Acacia* spp. and medium dense *Triodia* sp. within five years of regeneration from fire. Minor drainage lines exist with numerous rocky outcrops and continuous surface layer of small pebbles. |  |

| | |
|---|---|
| **GWA S3**<br>**Habitat type:** Mulga woodland<br>Moderately dense woodland consisting exclusively of mature Mulga (*Acacia ayersiana*) in very good condition on flat plain. Few shrub species consisting of *Eremophila* spp., *Mairina* sp. and various native grasses. Soil profile lose in firmness, with texture consisting of clay sand of reddish-brown colour. |  |
| **GWA S4**<br>**Habitat type:** Footslope and plain<br>Hummock spinifex grassland plain extending from footslopes of nearby rocky hills. Open tree species consisting of *Acacia aneura* and *Eucalyptus leucophloia*. Many shrub species of medium density consisting of *Acacia maitlandii, Acacia inaequilatera, Acacia* spp., *Senna* sp. *Eremophila* sp. and *Gossypoium robinsonii*. *Triodia* sp. in medium to high density in patches of early regeneration to mature. Soil loam clay with continuous surface layer of pebbles. |  |

| | |
|---|---|
| **GWA S5**<br>**Habitat type:** Footslope and plain<br>*Triodia* sp. hummock grassland on gentle sloping plain with large rocky range approximately 600 m to the south. Very scattered *Corymbia hamersleyana* and *Acacia aneura* trees, mixed open shrub species of *Acacia maitlandii, Acacia inaequilatera, Ptilotus* sp. and denser patches of *Acacia pruinocarpa*. Almost no leaf or wood litter, soil consisting of loam clay with a continuous layer of small surface pebbles. |  |
| **GWA S6**<br>**Habitat type: H**illtop, hillslope, cliff and ridge<br>Trapping site transects from foot to mid-slope of rocky hill towards a ridge. Dominated by *Triodia* sp. with scattered *Eucalyptus leucophloia* trees with shrub species consisting of *Acacia inaequilatera*, *Acacia maitlandii* and *Eremophila* sp., shrub species denser in minor drainage channels coming off the range. Numerous rocky outcrops. |  |

| | |
|---|---|
| **GWA S7**<br>**Habitat type:** Footslope and plain<br>Located on a sloping plain at the footslopes of a small range to the north. *Triodia* sp. shrubland with isolated denser patches of *Acacia aneura*. Other shrub species consisting of *Acacia pruinocarpa* and *Acacia maitlandii*. Soil consisting of loam clay with a continuous layer of small surface pebbles. |  |
| **GWA S8**<br>**Habitat type:** Cracking Clay<br>Flat tussock grassland plain with native grasses A*ristida latifolia, Astrebla pectinata* and *Brachyachne convergens* growing in open to very dense patches. Scattered and isolated *Acacia aneura* trees with *Acacia tetragonophylla* and *Acacia synchronicia* shrubs. Soil consisting of clay with wide vertical cracks within the soil profile. |  |

| | |
|---|---|
| **GWA S9**<br>**Habitat type:** Footslope and plain<br>Located within a small drainage line amongst an east-west orientated valley. *Triodia* sp. hummock grassland with occasional *Eucalyptus leucophloia, Eucalyptus gamophylla* and *Corymbia hamersleyana* trees. Shrub density within the drainage line is high, becoming scattered towards hills. Shrub species consisting of *Acacia inaequilatera, Senna* sp. and *Gossypium robinsonii*. Soil consisting of loam clay with a continuous layer of small surface pebbles and outcropping close to hills. |  |
| **GWA S10**<br>**Habitat type:** Mixed Acacia woodland<br>Open to medium dense woodland consisting mainly of *Acacia aneura* with scattered *Acacia pruinocarpa*. Shrubs consisting of *Acacia maitlandii* and *Ptilotus* sp. with *Triodia* sp. ground cover. Soil consisting of loam clay with a continuous layer of small surface pebbles. |  |

| | |
|---|---|
| **GWA S11**<br>**Habitat type:** Footslope and plain<br>A diverse site consisting of mix of *Triodia* sp. hummock and tussock grassland on a flat plain. Medium density of shrubs consisting of *Acacia maitlandii*, *Acacia tetragonophylla* and *Hakea lorea*. Tree species consisting of *Acacia aneura* and *Acacia pruinocarpa*. Soil characteristics variable with influence from nearby cracking clay (GWA S8) and more typical rocky plain. |  |
| **GWA S12**<br>**Habitat type:** Major gorge and gully<br>Hummock grassland located within mouth of gorge and extending drainage line on footslopes of nearby rocky hill. Dense, mature *Triodia* sp. with *Acacia maitlandii*, *Acacia pruinocarpa* and scattered *Eremophila* sp. shrubs. Regular *Eucalyptus leucophloia*, concentrated around the drainage line with *Acacia aneura* also present. Very rocky with exposed outcropping. |  |

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# APPENDIX D VERTEBRATE VOUCHER SPECIMENS LODGED WITH WA MUSEUM

| WA Museum specimen no. | Species | Site captured | Easting | Northing | Habitat |
|---|---|---|---|---|---|
| WAM TS099 | *Ctenotus rutilans* | GWA S4 | 690271 | 7434157 | Foot slope of rocky hill, moderately dense hummock grassland with open (clusters of denser areas) of mixed acacia spp. shrubs |

# APPENDIX E LITERATURE REVIEW OF POTENTIAL SPECIES

## Appendix E1: Mammals

| Family and Species | Common name | Conservation Status | | | *ecologia* internal database | Ninox 2009b | Ninox 1995 | HGM 1999a | HGM 1999b | Maunsell 2003 | Ninox 2009a | Ninox 1994 | Biota 2010 | NatureMap | DEC Threatened fauna | EPBC Protected matters | This survey |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | EPBC Act | WC Act | DEC | | | | | | | | | | | | | |
| **TACHYGLOSSIDAE** | | | | | | | | | | | | | | | | | |
| *Tachyglossus aculeatus* | Echidna | | | | ● | | | | | | | | | | | | |
| **DASYURIDAE** | | | | | | | | | | | | | | | | | |
| *Dasykaluta rosamondae* | Little Red Kaluta | | | | ● | ● | | | | | ● | | | ● | | | ● |
| *Dasyurus hallucatus* | Northern Quoll | **EN** | **S1** | **EN** | | | | | | | | | | ● | | ● | |
| *Ningaui timealeyi* | Pilbara Ningaui | | | | ● | ● | | ● | | | | | ● | ● | | | ● |
| *Planigale* sp. | Planigale | | | | ● | ● | | | | | | | | ● | | | ● |
| *Pseudantechinus roryi* | Rory's Pseudantechinus | | | | | | | | | | | | | ● | | | |
| *Pseudantechinus woolleyae* | Woolley's Pseudantechinus | | | | | ● | | | | | | | | ● | | | |
| *Sminthopsis dolichura* | Little Long-tailed Dunnart | | | | | | | | | | | | | ● | | | |
| *Sminthopsis macroura* | Stripe-faced Dunnart | | | | ● | | | | | | | | | ● | | | ● |
| *Sminthopsis youngsoni* | Lesser Hairy-footed Dunnart | | | | | | | | | | | | | ● | | | |
| *Sminthopsis ooldea* | Ooldea Dunnart | | | | ● | | | | | | | | | ● | | | ● |
| **THYLACOMYIDAE** | | | | | | | | | | | | | | | | | |
| *Macrotis lagotis* | Bilby | **VU** | **S1** | **VU** | ● | | ● | | | | | | | | | ● | |
| **MACROPODIDAE** | | | | | | | | | | | | | | | | | |
| *Macropus robustus* | Euro | | | | ● | | ● | ● | ● | ● | | ● | | ● | | | ● |
| *Macropus rufus* | Red Kangaroo | | | | ● | ● | ● | | ● | | | ● | | ● | | | ● |
| *Petrogale rothschildi* | Rothschild's Rock-wallaby | | | | ● | | ● | | | | | | | ● | | | ● |
| **PTEROPODIDAE** | | | | | | | | | | | | | | | | | |
| *Pteropus scapulatus* | Litte Red Flying-fox | | | | ● | | | | | | | | | | | | |
| **HIPPOSIDERIDAE** | | | | | | | | | | | | | | | | | |
| *Rhinonicteris aurantia* (Pilbara form) | Pilbara Leaf-nosed Bat | **VU** | **S1** | **VU** | | | | | | | | | | ● | | ● | ● |
| **MEGADERMATIDAE** | | | | | | | | | | | | | | | | | |
| *Macroderma gigas* | Ghost Bat | | | **P4** | ● | | | | | | | | | ● | ● | | |

| Family and Species | Common name | Conservation Status | | | *ecologia* internal database | Ninox 2009b | Ninox 1995 | HGM 1999a | HGM 1999b | Maunsell 2003 | Ninox 2009a | Ninox 1994 | Biota 2010 | NatureMap | DEC Threatened fauna | EPBC Protected matters | This survey |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | EPBC Act | WC Act | DEC | | | | | | | | | | | | | |
| **EMBALLONURIDAE** | | | | | | | | | | | | | | | | | |
| *Saccolaimus flaviventris* | Yellow-bellied Sheathtail Bat | | | | ● | ● | | | | | ● | | ● | ● | | | ● |
| *Taphozous georgianus* | Common Sheathtail Bat | | | | ● | ● | | | | | ● | | ● | ● | | | ● |
| *Taphozous hilli* | Hill's Sheathtail Bat | | | | ● | ● | | | | | | | | ● | | | |
| **VESPERTILIONIDAE** | | | | | | | | | | | | | | | | | |
| *Chalinolobus gouldii* | Gould's Wattled Bat | | | | ● | ● | | ● | | | ● | ● | ● | ● | | | ● |
| *Nyctophilus bifax daedalus* | Northwestern Long-eared Bat | | | | ● | | | | | | | | | | | | |
| *Nyctophilus geoffroyi* | Lesser Long-eared Bat | | | | ● | | | | | | | | | ● | | | ● |
| *Scotorepens greyii* | Little Broad-nosed Bat | | | | ● | ● | | | | | | ● | ● | ● | | | ● |
| *Vespadelus finlaysoni* | Finlayson's Cave Bat | | | | ● | ● | | | | | ● | ● | ● | ● | | | ● |
| **MOLOSSIDAE** | | | | | | | | | | | | | | | | | |
| *Chaerophon jobensis* | Northern Freetail Bat | | | | ● | ● | | ● | | | ● | | | ● | | | ● |
| *Mormopterus beccarii* | Beccari's Freetail Bat | | | | ● | ● | | | | | | | | ● | | | ● |
| *Mormopterus planiceps* | Southern Freetail Bat | | | | ● | | | | | | | | | | | | |
| *Tadarida australis* | White-striped Freetail Bat | | | | ● | ● | | ● | | | | | ● | ● | | | |
| **MURIDAE** | | | | | | | | | | | | | | | | | |
| *Leggadina lakedownensis* | Short-tailed Mouse | | | **P4** | | | | | | | | | | ● | ● | | |
| *Notomys alexis* | Spinifex Hopping-mouse | | | | | | | | | | | | | ● | | | |
| *Pseudomys chapmani* | Western Pebble-mound Mouse | | | **P4** | ● | ● | | ● | ● | ● | ● | ● | ● | ● | ● | | ● |
| *Pseudomys delicatulus* | Delicate Mouse | | | | | ● | | | | | | | | ● | | | ● |
| *Pseudomys desertor* | Desert Mouse | | | | ● | | | | | | ● | | | ● | | | ● |
| *Pseudomys hermannsburgensis* | Sandy Inland Mouse | | | | ● | ● | | ● | | | ● | ● | ● | ● | | | ● |
| *Zyzomys argurus* | Common Rock-rat | | | | ● | ● | | | | | | ● | ● | ● | | | ● |
| **CANIDAE** | | | | | | | | | | | | | | | | | |
| *Canis lupus dingo* | Dingo | | | | ● | | | ● | ● | | ● | ● | | ● | | | ● |
| **INTRODUCED MAMMALS** | | | | | | | | | | | | | | | | | |
| **Mus musculus* | House Mouse | | | | ● | | | ● | | | | ● | | ● | | | ● |

| Family and Species | Common name | Conservation Status | | | *ecologia* internal database | Ninox 2009b | Ninox 1995 | HGM 1999a | HGM 1999b | Maunsell 2003 | Ninox 2009a | Ninox 1994 | Biota 2010 | NatureMap | DEC Threatened fauna | EPBC Protected matters | This survey |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | EPBC Act | WC Act | DEC | | | | | | | | | | | | | |
| **Canis lupus familiaris* | Dog | | | | ● | | | | | | | | | ● | | | |
| **Vulpes vulpes* | Red Fox | | | | | | | | | | | | | | | ● | |
| **Felis catus* | Cat | | | | ● | | | | ● | ● | | ● | | ● | | ● | |
| **Oryctolagus cuniculus* | Rabbit | | | | ● | | | | | | | | | ● | | ● | ● |
| **Equus asinus* | Donkey | | | | ● | | ● | | | | | | ● | ● | | | |
| **Equus caballus* | Horse | | | | ● | | | | | | | | | ● | | | |
| **Camelus dromedarius* | Camel | | | | | | | | | | ● | | | ● | | | |
| **Bos taurus* | Cow | | | | ● | | ● | ● | | ● | ● | ● | ● | ● | | | |

## Appendix E2: Birds

| Family and Species | Common name | Conservation Status | | | *ecologia* internal database | Ninox 2009b | Ninox 1995 | HGM 1999a | HGM 1999b | Maunsell 2003 | Ninox 2009a | Ninox 1994 | Biota 2010 | NatureMap | Birdata | DEC Threatened fauna | EPBC Protected matters | This survey |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | EPBC Act | WC Act | DEC | | | | | | | | | | | | | | |
| **CASUARIIDAE** | | | | | | | | | | | | | | | | | | |
| *Dromaius novaehollandiae* | Emu | | | | ● | | ● | ● | | ● | | ● | | ● | | | | |
| **PHASIANIDAE** | | | | | | | | | | | | | | | | | | |
| *Coturnix ypsilophora* | Brown Quail | | | | | | | | | | | | | ● | | | | ● |
| *Coturnix pectoralis* | Stubble Quail | | | | | | | | | | | | ● | | ● | | | |
| **ANATIDAE** | | | | | | | | | | | | | | | | | | |
| *Dendrocygna eytoni* | Plumed Whistling-Duck | | | | | | | | | | | | | ● | | | | |
| *Tadorna tadornoides* | Australian Shelduck | | | | | | | | | | | | | ● | | | | |
| *Anas gracilis* | Grey Teal | | | | ● | | | ● | | | | ● | ● | | | | | |
| *Anas superciliosa* | Pacific Black Duck | | | | ● | | | ● | | ● | | | | ● | | | | |
| *Aythya australis* | Hardhead | | | | ● | | | | | | | | | | | | | |
| **COLUMBIDAE** | | | | | | | | | | | | | | | | | | |
| *Phaps chalcoptera* | Common Bronzewing | | | | ● | ● | ● | | | ● | | ● | | ● | ● | | | ● |
| *Ocyphaps lophotes* | Crested Pigeon | | | | ● | ● | ● | | ● | ● | | ● | ● | ● | ● | | | ● |
| *Geophaps plumifera* | Spinifex Pigeon | | | | ● | ● | ● | | ● | ● | | ● | ● | ● | ● | | | ● |
| *Geopelia cuneata* | Diamond Dove | | | | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● | | | ● |
| *Geopelia striata* | Peaceful Dove | | | | ● | | | | | ● | | ● | ● | ● | | | | |
| **PODARGIDAE** | | | | | | | | | | | | | | | | | | |
| *Podargus strigoides* | Tawny Frogmouth | | | | ● | | | ● | | | | | | ● | ● | | | ● |
| **EUROSTOPODIDAE** | | | | | | | | | | | | | | | | | | |
| *Eurostopodus argus* | Spotted Nightjar | | | | ● | ● | | ● | | ● | ● | ● | | ● | ● | | | ● |
| **AEGOTHELIDAE** | | | | | | | | | | | | | | | | | | |
| *Aegotheles cristatus* | Australian Owlet-nightjar | | | | ● | ● | | | ● | ● | | ● | | ● | ● | | | ● |
| **APODIDAE** | | | | | | | | | | | | | | | | | | |

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| *Apus pacificus* | Fork-tailed Swift | M | S3 | | ● | | | | | | | | | | | ● | ● | ● |
| **PHALACROCORACIDAE** | | | | | | | | | | | | | | | | | | |
| *Microcarbo melanoleucos* | Little Pied Cormorant | | | | ● | | | ● | | ● | | | ● | | | | | |
| *Phalacrocorax sulcirostris* | Little Black Cormorant | | | | ● | | | | | ● | | | | ● | | | | |
| **ARDEIDAE** | | | | | | | | | | | | | | | | | | |
| *Ardea pacifica* | White-necked Heron | | | | ● | | ● | ● | | | | | | ● | | | | |
| *Ardea modesta* | Eastern Great Egret | M | S3 | | | | | | | ● | | | | | | | ● | |
| *Ardea ibis* | Cattle Egret | M | S3 | | | | | | | | | | | | | | ● | |
| *Egretta novaehollandiae* | White-faced Heron | | | | ● | ● | | ● | | | | ● | | | | | | |
| *Nycticorax caledonicus* | Nankeen Night-Heron | | | | ● | | | | | ● | | | | | | | | |
| **THRESKIORNITHIDAE** | | | | | | | | | | | | | | | | | | |
| *Threskiornis spinicollis* | Straw-necked Ibis | | | | ● | | | | | | | | | | | | | ● |
| **ACCIPITRIDAE** | | | | | | | | | | | | | | | | | | |
| *Elanus axillaris* | Black-shouldered Kite | | | | ● | | | | | ● | | | | | | | | ● |
| *Lophoictinia isura* | Square-tailed Kite | | | | ● | | | | | | ● | | | | | | | |
| *Hamirostra melanosternon* | Black-breasted Buzzard | | | | ● | ● | | | | | | | | ● | | | | |
| *Haliastur sphenurus* | Whistling Kite | | | | ● | ● | | | | ● | | ● | ● | ● | | | | ● |
| *Milvus migrans* | Black Kite | | | | ● | | | | | | | | | ● | | | | |
| *Accipiter fasciatus* | Brown Goshawk | | | | ● | | | ● | | | | ● | | ● | | | | ● |
| *Accipiter cirrocephalus* | Collared Sparrowhawk | | | | ● | | | ● | | ● | | ● | | ● | ● | | | ● |
| *Circus assimilis* | Spotted Harrier | | | | ● | | ● | ● | | | | ● | | ● | ● | | | ● |
| *Aquila audax* | Wedge-tailed Eagle | | | | ● | ● | | | | | | | | ● | ● | | | ● |
| *Hieraaetus morphnoides* | Little Eagle | | | | ● | | | ● | | ● | | | ● | ● | | | | ● |
| **FALCONIDAE** | | | | | | | | | | | | | | | | | | |
| *Falco cenchroides* | Nankeen Kestrel | | | | ● | ● | | | ● | ● | | ● | ● | ● | ● | | | ● |
| *Falco berigora* | Brown Falcon | | | | ● | ● | ● | ● | | ● | ● | ● | | ● | ● | | | ● |

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| *Falco longipennis* | Australian Hobby | | | | ● | ● | | ● | ● | ● | | ● | | ● | | | | ● |
| *Falco hypoleucos* | Grey Falcon | | **S1** | **VU** | ● | | | | | | | | | ● | | ● | | |
| *Falco peregrinus* | Peregrine Falcon | | **S4** | **Other** | ● | | | | | | | ● | | | | | | |
| **OTIDIDAE** | | | | | | | | | | | | | | | | | | |
| *Ardeotis australis* | Australian Bustard | | | **P4** | ● | ● | ● | ● | ● | | ● | ● | | ● | ● | ● | | ● |
| **BURHINIDAE** | | | | | | | | | | | | | | | | | | |
| *Burhinus grallarius* | Bush Stone-curlew | | | **P4** | | | | | | | | | | ● | | ● | | ● |
| **RECURVIROSTRIDAE** | | | | | | | | | | | | | | | | | | |
| *Himantopus himantopus* | Black-winged Stilt | | | | | | | | | | | | | ● | | | | |
| **CHARADRIIDAE** | | | | | | | | | | | | | | | | | | |
| *Charadrius veredus* | Oriental Plover | **M** | **S3** | | | | | | | | | | | | | | ● | |
| *Elseyornis melanops* | Black-fronted Dotterel | | | | ● | | | ● | | ● | | ● | | ● | | | | |
| **SCOLOPACIDAE** | | | | | | | | | | | | | | | | | | |
| *Actitis hypoleucos* | Common Sandpiper | **M** | **S3** | | | | | | | ● | | | | | | | | |
| **TURNICIDAE** | | | | | | | | | | | | | | | | | | |
| *Turnix velox* | Little Button-quail | | | | ● | | ● | ● | ● | | | ● | | ● | ● | | | ● |
| **CACATUIDAE** | | | | | | | | | | | | | | | | | | |
| *Eolophus roseicapillus* | Galah | | | | ● | ● | ● | ● | | ● | ● | ● | | ● | ● | | | ● |
| *Cacatua sanguinea* | Little Corella | | | | ● | ● | | ● | ● | ● | ● | ● | ● | ● | ● | | | |
| *Nymphicus hollandicus* | Cockatiel | | | | ● | | | ● | | | | | | ● | | | | ● |
| **PSITTACIDAE** | | | | | | | | | | | | | | | | | | |
| *Barnardius zonarius* | Australian Ringneck | | | | ● | ● | ● | | ● | ● | ● | ● | ● | | ● | | | ● |
| *Psephotus varius* | Mulga Parrot | | | | ● | | | | | | | | | | | | | ● |
| *Melopsittacus undulatus* | Budgerigar | | | | ● | ● | ● | ● | ● | | ● | ● | | ● | ● | | | ● |
| *Neopsephotus bourkii* | Bourke's Parrot | | | | ● | | | | | | | | | | | | | |
| *Pezoporus occidentalis* | Night Parrot | **EN** | **S1** | **CR** | | | | | | | | | | | | | ● | |

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| **CUCULIDAE** | | | | | | | | | | | | | | | | | | |
| *Centropus phasianinus* | Pheasant Coucal | | | | | | | | | | | | ● | | | | | |
| *Chalcites basalis* | Horsfield's Bronze-Cuckoo | | | | ● | ● | | ● | | ● | ● | | ● | ● | ● | | | ● |
| *Chalcites osculans* | Black-eared Cuckoo | | | | ● | | | | ● | | | | | | ● | | | |
| *Cacomantis pallidus* | Pallid Cuckoo | | | | ● | ● | ● | ● | ● | | ● | | | | ● | | | |
| **STRIGIDAE** | | | | | | | | | | | | | | | | | | |
| *Ninox connivens* | Barking Owl | | | | | ● | | | | ● | | ● | | | | | | |
| *Ninox novaeseelandiae* | Southern Boobook | | | | ● | | | ● | | | | ● | | ● | | | | ● |
| **TYTONIDAE** | | | | | | | | | | | | | | | | | | |
| *Tyto javanica* | Eastern Barn Owl | | | | ● | | | | | | | | | | | | | ● |
| **HALCYONIDAE** | | | | | | | | | | | | | | | | | | |
| *Dacelo leachii* | Blue-winged Kookaburra | | | | ● | | | ● | | ● | | | ● | | | | | |
| *Todiramphus pyrrhopygius* | Red-backed Kingfisher | | | | ● | ● | | ● | | ● | ● | ● | ● | ● | ● | | | ● |
| *Todiramphus sanctus* | Sacred Kingfisher | | | | ● | ● | ● | ● | ● | | | ● | | ● | | | | |
| **MEROPIDAE** | | | | | | | | | | | | | | | | | | |
| *Merops ornatus* | Rainbow Bee-eater | **M** | **S3** | | ● | | | ● | ● | ● | | ● | ● | ● | | ● | ● | |
| **CLIMACTERIDAE** | | | | | | | | | | | | | | | | | | |
| *Climacteris melanura* | Black-tailed Treecreeper | | | | ● | | ● | ● | | | | ● | | | | | | |
| **PTILONORHYNCHIDAE** | | | | | | | | | | | | | | | | | | |
| *Ptilonorhynchus guttatus* | Western Bowerbird | | | | ● | ● | | ● | ● | ● | | ● | | ● | ● | | | ● |
| **MALURIDAE** | | | | | | | | | | | | | | | | | | |
| *Malurus splendens* | Splendid Fairy-wren | | | | ● | | | | | | | | | ● | ● | | | ● |
| *Malurus leucopterus* | White-winged Fairy-wren | | | | ● | ● | ● | ● | | ● | | ● | | ● | ● | | | ● |
| *Malurus lamberti* | Variegated Fairy-wren | | | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | | ● |
| *Stipiturus ruficeps* | Rufous-crowned Emu-wren | | | | ● | ● | | | | ● | | | | ● | ● | | | ● |
| *Amytornis striatus* | Striated Grasswren | | | | ● | ● | | ● | | ● | | | | ● | ● | | | |

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| **ACANTHIZIDAE** | | | | | | | | | | | | | | | | | | |
| *Pyrrholaemus brunneus* | Redthroat | | | | | | | | | | | | | ● | ● | | | |
| *Smicrornis brevirostris* | Weebill | | | | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● | | | ● |
| *Gerygone fusca* | Western Gerygone | | | | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● | | | ● |
| *Acanthiza robustirostris* | Slaty-backed Thornbill | | | | ● | | | | | | | ● | | ● | ● | | | |
| *Acanthiza chrysorrhoa* | Yellow-rumped Thornbill | | | | ● | | | | | | | | | ● | | | | |
| *Acanthiza uropygialis* | Chestnut-rumped Thornbill | | | | ● | ● | ● | | | | ● | ● | | ● | ● | | | ● |
| *Acanthiza apicalis* | Inland Thornbill | | | | ● | ● | | | ● | | ● | | | ● | ● | | | ● |
| **PARDALOTIDAE** | | | | | | | | | | | | | | | | | | |
| *Pardalotus rubricatus* | Red-browed Pardalote | | | | ● | | ● | ● | | ● | | ● | ● | ● | | | | ● |
| *Pardalotus striatus* | Striated Pardalote | | | | ● | ● | ● | ● | ● | ● | | ● | ● | ● | ● | | | ● |
| **MELIPHAGIDAE** | | | | | | | | | | | | | | | | | | |
| *Certhionyx variegatus* | Pied Honeyeater | | | | ● | | | ● | | | | | | ● | | | | |
| *Lichenostomus virescens* | Singing Honeyeater | | | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | | ● |
| *Lichenostomus keartlandi* | Grey-headed Honeyeater | | | | ● | ● | ● | ● | | ● | ● | ● | ● | ● | ● | | | ● |
| *Lichenostomus penicillatus* | White-plumed Honeyeater | | | | ● | ● | | ● | ● | ● | | ● | ● | ● | ● | | | |
| *Purnella albifrons* | White-fronted Honeyeater | | | | ● | | ● | | | | | ● | | | | | | ● |
| *Manorina flavigula* | Yellow-throated Miner | | | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | | ● |
| *Acanthagenys rufogularis* | Spiny-cheeked Honeyeater | | | | ● | ● | ● | | | ● | ● | | ● | ● | ● | | | ● |
| *Conopophila whitei* | Grey Honeyeater | | | | ● | | | | | | | | | ● | | | | ● |
| *Epthianura tricolor* | Crimson Chat | | | | ● | | | ● | | ● | | ● | | ● | ● | | | ● |
| *Sugomel niger* | Black Honeyeater | | | | ● | | | ● | | | | ● | | ● | ● | | | |
| *Lichmera indistincta* | Brown Honeyeater | | | | ● | | ● | ● | ● | ● | | ● | ● | ● | ● | | | ● |
| *Melithreptus gularis* | Black-chinned Honeyeater | | | | ● | | | | | ● | | | | ● | | | | ● |
| **POMATOSTOMIDAE** | | | | | | | | | | | | | | | | | | |
| *Pomatostomus temporalis* | Grey-crowned Babbler | | | | ● | ● | ● | ● | | ● | ● | ● | ● | ● | ● | | | ● |

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| *Pomatostomus superciliosus* | White-browed Babbler | | | | ● | | ● | | ● | | | | | ● | ● | | | ● |
| **PSOPHODIDAE** | | | | | | | | | | | | | | | | | | |
| *Cinclosoma castaneothorax* | Chestnut-breasted Quail-thrush | | | | ● | | | | | | | | | | | | | |
| **NEOSITTIDAE** | | | | | | | | | | | | | | | | | | |
| *Daphoenositta chrysoptera* | Varied Sittella | | | | ● | | | | | | | | | ● | ● | | | |
| **CAMPEPHAGIDAE** | | | | | | | | | | | | | | | | | | |
| *Coracina maxima* | Ground Cuckoo-shrike | | | | ● | | | | | | ● | | | ● | ● | | | |
| *Coracina novaehollandiae* | Black-faced Cuckoo-shrike | | | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | | ● |
| *Lalage sueurii* | White-winged Triller | | | | ● | ● | ● | ● | ● | ● | | ● | | ● | ● | | | ● |
| **PACHYCEPHALIDAE** | | | | | | | | | | | | | | | | | | |
| *Pachycephala rufiventris* | Rufous Whistler | | | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | | ● |
| *Colluricincla harmonica* | Grey Shrike-thrush | | | | ● | ● | | ● | ● | ● | ● | ● | ● | ● | ● | | | ● |
| *Oreoica gutturalis* | Crested Bellbird | | | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | | ● |
| **ARTAMIDAE** | | | | | | | | | | | | | | | | | | |
| *Artamus personatus* | Masked Woodswallow | | | | ● | ● | | | ● | | | ● | ● | ● | | | | ● |
| *Artamus cinereus* | Black-faced Woodswallow | | | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | | ● |
| *Artamus minor* | Little Woodswallow | | | | ● | ● | | | | ● | | | ● | ● | ● | | | ● |
| *Cracticus torquatus* | Grey Butcherbird | | | | ● | ● | ● | | | | ● | ● | | ● | ● | | | ● |
| *Cracticus nigrogularis* | Pied Butcherbird | | | | ● | ● | ● | ● | ● | ● | ● | ● | | ● | ● | | | ● |
| *Cracticus tibicen* | Australian Magpie | | | | ● | ● | | ● | ● | ● | ● | ● | | ● | ● | | | ● |
| **RHIPIDURIDAE** | | | | | | | | | | | | | | | | | | |
| *Rhipidura albiscapa* | Grey Fantail | | | | ● | ● | | | | | ● | | | ● | ● | | | ● |
| *Rhipidura leucophrys* | Willie Wagtail | | | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | | ● |
| **CORVIDAE** | | | | | | | | | | | | | | | | | | |
| *Corvus bennetti* | Little Crow | | | | ● | ● | | | | | | | ● | ● | ● | | | ● |
| *Corvus orru* | Torresian Crow | | | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | | ● |

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| **MONARCHIDAE** | | | | | | | | | | | | | | | | | | |
| *Grallina cyanoleuca* | Magpie-lark | | | | ● | ● | | ● | ● | ● | ● | ● | ● | ● | ● | | | ● |
| **PETROICIDAE** | | | | | | | | | | | | | | | | | | |
| *Petroica goodenovii* | Red-capped Robin | | | | ● | ● | ● | | ● | | ● | ● | | ● | ● | | | ● |
| *Melanodryas cucullata* | Hooded Robin | | | | ● | ● | ● | ● | ● | ● | | ● | ● | ● | ● | | | ● |
| **ALAUDIDAE** | | | | | | | | | | | | | | | | | | |
| *Mirafra javanica* | Horsfield's Bushlark | | | | ● | | | | | | | | | ● | | | | ● |
| **ACROCEPHALIDAE** | | | | | | | | | | | | | | | | | | |
| *Acrocephalus australis* | Australian Reed-Warbler | | | | | | | | | ● | | | | | | | | |
| **MEGALURIDAE** | | | | | | | | | | | | | | | | | | |
| *Cincloramphus mathewsi* | Rufous Songlark | | | | ● | | | ● | | ● | | ● | ● | ● | ● | | | ● |
| *Cincloramphus cruralis* | Brown Songlark | | | | ● | | | ● | | | | | | | | | | ● |
| *Eremiornis carteri* | Spinifexbird | | | | ● | ● | ● | ● | | ● | | | | ● | ● | | | ● |
| **HIRUNDINIDAE** | | | | | | | | | | | | | | | | | | |
| *Petrochelidon ariel* | Fairy Martin | | | | ● | | | ● | | | | | | | ● | | | |
| *Petrochelidon nigricans* | Tree Martin | | | | ● | | | ● | | | ● | ● | ● | ● | ● | | | |
| **NECTARINIIDAE** | | | | | | | | | | | | | | | | | | |
| *Dicaeum hirundinaceum* | Mistletoebird | | | | ● | ● | ● | | | ● | | ● | | ● | ● | | | ● |
| **ESTRILDIDAE** | | | | | | | | | | | | | | | | | | |
| *Taeniopygia guttata* | Zebra Finch | | | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | | ● |
| *Neochmia ruficauda subclarescens* | Star Finch (western) | | | **P4** | ● | | | | | | | | ● | ● | | | | |
| *Emblema pictum* | Painted Finch | | | | ● | ● | ● | ● | | ● | ● | ● | ● | ● | ● | | | ● |
| **MOTACILLIDAE** | | | | | | | | | | | | | | | | | | |
| *Anthus novaeseelandiae* | Australasian Pipit | | | | ● | ● | | ● | ● | | ● | | | ● | | | | ● |

## Appendix E3: Reptiles

| Family and Species | Common name | Conservation Status | | | *ecologia* internal database | Ninox 2009b | Ninox 1995 | HGM 1999a | HGM 1999b | Maunsell 2003 | Ninox 2009a | Ninox 1994 | Biota 2010 | NatureMap | DEC Threatened fauna | EPBC Protected matters | This survey |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | EPBC Act | WC Act | DEC | | | | | | | | | | | | | |
| **CHELUIDAE** | | | | | | | | | | | | | | | | | |
| *Chelodina steindachneri* | Flat-shelled Turtle | | | | | | | | | | | | | ● | | | |
| **AGAMIDAE** | | | | | | | | | | | | | | | | | |
| *Amphibolurus longirostris* | | | | | ● | ● | ● | ● | ● | | ● | ● | ● | ● | | | ● |
| *Caimanops amphiboluroides* | | | | | ● | | | | | | ● | | | | | | |
| *Ctenophorus caudicinctus* | Ring-tailed Dragon | | | | ● | ● | ● | ● | | | ● | ● | ● | ● | | | ● |
| *Ctenophorus isolepis* | Central Military Dragon | | | | ● | | | ● | | | | ● | ● | ● | | | |
| *Ctenophorus nuchalis* | Central Netted Dragon | | | | ● | | | | | | | ● | | | | | |
| *Ctenophorus reticulatus* | Western Netted Dragon | | | | ● | | | | | | ● | | | ● | | | |
| *Diporiphora valens* | | | | | ● | | | | | | | | | ● | | | ● |
| *Diporiphora winneckei* | Blue-lined Dragon | | | | | | | | | | | | | ● | | | |
| *Pogona minor* | Dwarf Bearded Dragon | | | | ● | ● | | | | | ● | ● | | ● | | | ● |
| *Tympanocryptis cephalus* | Pebble Dragon | | | | | | | | | | | | | ● | | | ● |
| **DIPLODACTYLIDAE** | | | | | | | | | | | | | | | | | |
| *Crenadactylus ocellatus* | Clawless Gecko | | | | ● | | | | | | | | | ● | | | |
| *Diplodactylus conspicillatus* | Fat-tailed Gecko | | | | ● | | | | | | | ● | | ● | | | |
| *Diplodactylus pulcher* | | | | | ● | ● | | | | | | | | ● | | | ● |
| *Diplodactylus savagei* | | | | | ● | ● | | | | | | | | ● | | | ● |
| *Lucasium stenodactylum* | | | | | ● | ● | | | | ● | | ● | ● | ● | | | ● |
| *Lucasium wombeyi* | | | | | ● | | | | | | | | | ● | | | ● |
| *Oedura marmorata* | Marbled Velvet Gecko | | | | ● | | | | | ● | | ● | ● | ● | | | ● |
| *Rhynchoedura ornata* | Beaked Gecko | | | | ● | ● | | ● | | | | ● | | ● | | | ● |
| *Strophurus elderi* | | | | | ● | | | | | | | | | ● | | | ● |
| *Strophurus jeanae* | | | | | ● | | | | | | | | | | | | |
| *Strophurus strophurus* | | | | | ● | | | | | | | | | | | | |

| Family and Species | Common name | Conservation Status | | | *ecologia* internal database | Ninox 2009b | Ninox 1995 | HGM 1999a | HGM 1999b | Maunsell 2003 | Ninox 2009a | Ninox 1994 | Biota 2010 | NatureMap | DEC Threatened fauna | EPBC Protected matters | This survey |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | EPBC Act | WC Act | DEC | | | | | | | | | | | | | |
| *Strophurus wellingtonae* | | | | | ● | ● | | | | | | | | ● | | | ● |
| **CARPHODACTYLIDAE** | | | | | | | | | | | | | | | | | |
| *Nephrurus wheeleri* | | | | | ● | | | | | | | | | ● | | | ● |
| *Underwoodisaurus seorsus* | | | | | ● | | | | | | | | | ● | | | ● |
| **GEKKONIDAE** | | | | | | | | | | | | | | | | | |
| *Gehyra pilbara* | | | | | | | ● | | | | | ● | | ● | | | |
| *Gehyra punctata* | | | | | ● | ● | | ● | | | | | ● | ● | | | ● |
| *Gehyra variegata* | | | | | ● | ● | | ● | | ● | ● | ● | | ● | | | ● |
| *Heteronotia binoei* | Bynoe's Gecko | | | | ● | ● | | ● | | ● | ● | ● | | ● | | | ● |
| *Heteronotia spelea* | Desert Cave Gecko | | | | ● | | | | | | | | | ● | | | ● |
| **PYGOPODIDAE** | | | | | | | | | | | | | | | | | |
| *Delma butleri* | | | | | ● | | | | | | | | | | | | |
| *Delma elegans* | | | | | ● | | | | | | | | | ● | | | ● |
| *Delma haroldi* | | | | | ● | | | | | | | | | ● | | | |
| *Delma nasuta* | | | | | ● | ● | | | | | ● | | ● | ● | | | ● |
| *Delma pax* | | | | | ● | ● | | | | | ● | | ● | ● | | | ● |
| *Delma tincta* | | | | | ● | ● | | | | | ● | | | ● | | | ● |
| *Lialis burtonis* | | | | | ● | | | ● | | | ● | | | ● | | | ● |
| *Pygopus nigriceps* | | | | | ● | | | | | | | | | ● | | | ● |
| **SCINCIDAE** | | | | | | | | | | | | | | | | | |
| *Carlia munda* | | | | | ● | ● | | ● | | | ● | ● | ● | ● | | | ● |
| *Carlia triacantha* | | | | | ● | ● | | | | | | | | ● | | | ● |
| *Cryptoblepharus buchananii* | | | | | | ● | | | | | | | | ● | | | |
| *Cryptoblepharus ustulatus* | | | | | ● | ● | | | | | | ● | | ● | | | ● |
| *Ctenotus ariadnae* | | | | | | | | | | | | | | ● | | | |
| *Ctenotus duricola* | | | | | ● | ● | | ● | | | ● | ● | | ● | | | ● |

| Family and Species | Common name | Conservation Status | | | *ecologia* internal database | Ninox 2009b | Ninox 1995 | HGM 1999a | HGM 1999b | Maunsell 2003 | Ninox 2009a | Ninox 1994 | Biota 2010 | NatureMap | DEC Threatened fauna | EPBC Protected matters | This survey |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | EPBC Act | WC Act | DEC | | | | | | | | | | | | | |
| *Ctenotus grandis* | | | | | ● | | | | | | | | | ● | | | |
| *Ctenotus hanloni* | | | | | ● | | | | | | | | ● | | | | |
| *Ctenotus helenae* | | | | | ● | ● | | | | | | ● | | ● | | | ● |
| *Ctenotus leonhardii* | | | | | ● | | | | | | | | | ● | | | |
| *Ctenotus pantherinus* | Leopard Ctenotus | | | | ● | ● | | ● | | | ● | ● | ● | ● | | | ● |
| *Ctenotus piankai* | | | | | ● | | | | | | | | | | | | |
| *Ctenotus robustus* | | | | | | | | | | | | | | | | | ● |
| *Ctenotus rubicundus* | | | | | ● | | | | | | | | ● | ● | | | |
| *Ctenotus rutilans* | | | | | ● | ● | | | | | ● | | | ● | | | ● |
| *Ctenotus saxatilis* | Rock Ctenotus | | | | ● | ● | | | | | ● | ● | | ● | | | ● |
| *Ctenotus schomburgkii* | | | | | ● | ● | | | | | ● | | | ● | | | ● |
| *Ctenotus serventyi* | | | | | ● | | | ● | | | | | | ● | | | |
| *Ctenotus uber* | | | | | ● | ● | | | | | | | | ● | | | |
| *Cyclodomorphus melanops* | Slender Blue-tongue | | | | ● | ● | ● | ● | | | ● | | ● | ● | | | ● |
| *Egernia cygnitos* | Western Pilbara Spiny-tail Skink | | | | ● | | | | | | | | | ● | | | ● |
| *Egernia formosa* | | | | | ● | | | | | | | ● | | ● | | | ● |
| *Egernia pilbarensis* | Pilbara Skink | | | | ● | | ● | | | | | ● | | | | | |
| *Eremiascincus fasciolatus* | Narrow-banded Sand Swimmer | | | | | | | | | | | | | ● | | | |
| *Eremiascincus richardsonii* | Broad-banded Sand Swimmer | | | | | | | | | | ● | | | ● | | | |
| *Lerista flammicauda* | | | | | | | | | | | | | | ● | | | |
| *Lerista jacksoni* | (L. muelleri group) | | | | | | | | | | | | | ● | | | |
| *Lerista labialis* | | | | | | | | | | | | ● | | | | | |
| *Lerista macropisthopus* | | | | | | | | | | | | | | ● | | | |
| *Lerista muelleri* | | | | | ● | ● | | | | | ● | | | ● | | | ● |
| *Lerista neander* | | | | | ● | ● | | | | | | | | ● | | | ● |
| *Lerista timida* | | | | | | | | | | | | | | | | | ● |

| Family and Species | Common name | Conservation Status | | | *ecologia* internal database | Ninox 2009b | Ninox 1995 | HGM 1999a | HGM 1999b | Maunsell 2003 | Ninox 2009a | Ninox 1994 | Biota 2010 | NatureMap | DEC Threatened fauna | EPBC Protected matters | This survey |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | EPBC Act | WC Act | DEC | | | | | | | | | | | | | |
| *Lerista verhmens* | | | | | | | | | | | | | | | | | ● |
| *Lerista zietzi* | | | | | ● | | | ● | | | | | | ● | | | ● |
| *Menetia greyii* | | | | | ● | | | | | | ● | ● | | ● | | | ● |
| *Menetia surda* | | | | | ● | ● | | | | | | | | ● | | | |
| *Morethia ruficauda* | | | | | ● | ● | | | | | | ● | | ● | | | ● |
| *Notoscincus ornatus* | | | | | | | | | | | | ● | | | | | |
| *Tiliqua multifasciata* | Central Blue-tongue | | | | ● | ● | | | | | ● | | | ● | | | ● |
| **VARANIDAE** | | | | | | | | | | | | | | | | | |
| *Varanus acanthurus* | Spiny-tailed Monitor | | | | ● | ● | | ● | | | | | | ● | | | ● |
| *Varanus brevicauda* | Short-tailed Pygmy Monitor | | | | ● | ● | | | | | | | | ● | | | ● |
| *Varanus bushi* | Pilbara Mulga Monitor | | | | | | | ● | | | | | | ● | | | ● |
| *Varanus caudolineatus* | | | | | ● | | | | | | | | | ● | | | |
| *Varanus giganteus* | Perentie | | | | ● | | | | | | | | | ● | | | ● |
| *Varanus gouldii* | Sand Monitor | | | | ● | | | | | | | ● | | ● | | | |
| *Varanus panoptes* | Yellow-spotted Monitor | | | | ● | ● | | ● | | | | | | ● | | | ● |
| *Varanus pilbarensis* | Pilbara Rock Monitor | | | | ● | | | | | ● | | ● | | ● | | | |
| *Varanus tristis tristis* | Racehorse Monitor | | | | ● | ● | | | | | | ● | | ● | | | ● |
| **TYPHLOPIDAE** | | | | | | | | | | | | | | | | | |
| *Ramphotyphlops ammodytes* | | | | | | | | | | | | | | ● | | | |
| *Ramphotyphlops ganei* | | | | **P1** | | | | | | | | | | ● | ● | | |
| *Ramphotyphlops grypus* | | | | | ● | ● | | | | | | | | ● | | | |
| *Ramphotyphlops hamatus* | | | | | ● | ● | | | | | | | | ● | | | |
| *Ramphotyphlops pilbarensis* | | | | | | | | | | | | | | ● | | | |
| **BOIDAE** | | | | | | | | | | | | | | | | | |
| *Antaresia perthensis* | Pygmy Python | | | | ● | | | | | | | | | ● | | | ● |
| *Antaresia stimsoni* | Stimson's Python | | | | ● | | | | | | | | | ● | | | |

| Family and Species | Common name | Conservation Status | | | *ecologia* internal database | Ninox 2009b | Ninox 1995 | HGM 1999a | HGM 1999b | Maunsell 2003 | Ninox 2009a | Ninox 1994 | Biota 2010 | NatureMap | DEC Threatened fauna | EPBC Protected matters | This survey |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | EPBC Act | WC Act | DEC | | | | | | | | | | | | | |
| *Aspidites melanocephalus* | Black-headed Python | | | | ● | | | | | | | | | ● | | | |
| *Liasis olivaceus barroni* | Pilbara Olive Python | **VU** | **S1** | **VU** | ● | | | ● | | ● | | | | ● | ● | ● | |
| **ELAPIDAE** | | | | | | | | | | | | | | | | | |
| *Acanthophis wellsi* | Pilbara Death Adder | | | | ● | ● | | | | | | | | ● | | | ● |
| *Brachyurophis approximans* | | | | | ● | | | | | | | | | ● | | | ● |
| *Demansia psammophis* | Yellow-faced Whipsnake | | | | ● | | | ● | | | ● | | ● | ● | | | ● |
| *Demansia rufescens* | Rufous Whipsnake | | | | ● | | | ● | | | | | | ● | | | ● |
| *Furina ornata* | Moon Snake | | | | ● | | | | | ● | | | | ● | | | ● |
| *Parasuta monachus* | Hooded Snake | | | | ● | ● | | | | | | | | ● | | | ● |
| *Pseudechis australis* | Mulga Snake | | | | ● | ● | | ● | | ● | | | | ● | | | ● |
| *Pseudonaja mengdeni* | Western Brown Snake | | | | ● | | | | | | | | | ● | | | ● |
| *Pseudonaja modesta* | Ringed Brown Snake | | | | ● | | | | | | | | | ● | | | ● |
| *Suta fasciata* | Rosen's Snake | | | | | ● | | | | | | | | ● | | | ● |
| *Suta punctata* | Spotted Snake | | | | | | | | | | | | | ● | | | |
| *Vermicella snelli* | Pilbara Bandy Bandy | | | | | | | | | | | | | | | | ● |

## Appendix E4: Amphibians

| Family and Species | Common name | Conservation Status | | | *ecologia* internal database | Ninox 2009b | Ninox 1995 | HGM 1999a | HGM 1999b | Maunsell 2003 | Ninox 2009a | Ninox 1994 | Biota 2010 | NatureMap | DEC Threatened fauna | EPBC Protected matters | This survey |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | EPBC Act | WC Act | DEC | | | | | | | | | | | | | |
| **HYLIDAE** | | | | | | | | | | | | | | | | | |
| *Cyclorana maini* | Sheep Frog | | | | ● | ● | | | | | ● | ● | | ● | | | |
| *Litoria rubella* | Little Red Tree Frog | | | | ● | | ● | | ● | | | ● | | ● | | | |
| **LIMNODYNASTIDAE** | | | | | | | | | | | | | | | | | |
| *Neobatrachus aquilonius* | Northern Burrowing Frog | | | | | | | | | | | | | ● | | | |
| *Neobatrachus sutor* | Shoemaker Frog | | | | | | | | | | | | | ● | | | |
| *Notaden nichollsi* | Desert Spadefoot | | | | ● | | | | | | | | | | | | |
| *Platyplectrum spenceri* | Centralian Burrowing Frog | | | | ● | | | | | | | | | | | | |
| **MYOBATRACHIDAE** | | | | | | | | | | | | | | | | | |
| *Pseudophryne douglasi* | Gorge Toadlet | | | | | | | | | | | | | ● | | | |
| *Uperoleia russelli* | Northwest Toadlet | | | | ● | | | | | | | | | | | | |

## Appendix E5: Previous SRE species recorded from the region

| Class (Order) | Family | Taxa | SRE status* |
|---|---|---|---|
| **Arachnida (Araneae)** | | | |
| | Miturgidae | 'Genus indet.' 'sp. indent.' | Potential |
| | Selenopidae | *Anyphops* 'sp. indent.' | Potential |
| **Arachnida (Mygalomorphae)** | | | |
| | Actinopodidae | *Missulena* 'sp. indent.' | Potential |
| | Actinopodidae | *Missulena* `MYG044` | Potential |
| | Barychelidae | *Synothele* `MYG055` | Potential |
| | Idiopidae | *Aganippe* `MYG083` | Potential |
| | Idiopidae | *Aganippe* 'sp (female)` | Potential |
| | Idiopidae | *Anidiops* `MYG083` | Potential |
| | Nemesiidae | *Chenistonia* `MYG088 female` | Potential |
| | Nemesiidae | *Chenistonia* `MYG088` | Potential |
| | Nemesiidae | *Teyl* `MYG027` | Potential |
| | Nemesiidae | *Yilgarnia* `MYG197` | Potential |
| **Arachnida (Pseudoscorpiones)** | | | |
| | Chthoniidae | *Austrochthonius* 'sp. indet.' | Potential |
| | Olpiidae | *Austrohorus* 'sp. indet.' | Potential |
| | Olpiidae | *Austrohorus* 'sp. A' | Unknown |
| | Olpiidae | *Austrohorus* 'sp. B.' | Unknown |
| | Olpiidae | *Beierolpium* 'sp. indet.' | Potential |
| | Olpiidae | *Beierolpium 'sp 8/2'* | Potential |
| | Olpiidae | *Beierolpium 'sp 8/3'* | Potential |
| | Olpiidae | *Beierolpium 'sp 8/4 small'* | Potential |
| **Arachnida (Scorpiones)** | | | |
| | Urodacidae | *Urodacus* 'sp. indent.' | Potential |
| **Chilopoda (Geophilomorpha)** | | | |
| | Unknown | 'Genus indet.' 'sp. indent.' | Unknown |
| **Diplopoda (Polydesmida)** | | | |
| | Paradoxosomatidae | *Antichiropis* sp. | Potential |
| | Paradoxosomatidae | *Antichiropus* `DIP006` | Potential |
| | Paradoxosomatidae | *Antichiropus* `DIP007 (?, female)` | Potential |
| | Paradoxosomatidae | *Antichiropus* `DIP007 (?, juv.)` | Potential |
| | Paradoxosomatidae | *Antichiropus* `DIP007` | Potential |
| | Paradoxosomatidae | *Antichiropus* `Wonmunna` | Potential |
| **Gastropoda (Stylommatophora)** | | | |
| | Camaenidae | Gen. Nov. sp. Z | Potential |
| | Camaenidae | Gen. Nov. sp. `small Mount Robinson` | Potential |
| | Succineidae | *Succinea* sp. | Potential |
| **Myriapoda (Geophilomorpha)** | | | |
| | Geophilidae | 'Genus indet.' 'sp. indent.' | Potential |

* SRE status defined in Section 3.5

# APPENDIX F FAUNA SPECIES RECORDED DURING SURVEY

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## Appendix E1: Mammals site x species matrix

| FAMILY and species | Common name | EPBC Act | WC Act | DEC | GWA s1 | | GWA s2 | | GWA s3 | | GWA s4 | | GWA s5 | | GWA s6 | | GWA s7 | | GWA s8 | | GWA s9 | | GWA s10 | | GWA s11 | | GWA s12 | | GWA Opp | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 |
| **DASYURIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Dasykaluta rosamondae* | Little Red Kaluta | | | | | | 1 | | | | | 10 | 1 | 7 | | 4 | 2 | 6 | | | | | | 2 | | 1 | | | | |
| *Ningaui timealeyi* | Pilbara Ningaui | | | | | 1 | 4 | 2 | 1 | 4 | | 5 | 1 | 1 | | | | 1 | | | | | 2 | 1 | 1 | 1 | 7 | 3 | | |
| *Planigale sp.* | Planigale | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | 1 | | |
| *Sminthopsis macroura* | Stripe-faced Dunnart | | | | 3 | 1 | 1 | | 2 | 1 | | 6 | | 1 | | 1 | | | 7 | | 2 | 1 | | | 2 | 4 | | 3 | | |
| *Sminthopsis ooldea* | Ooldea Dunnart | | | | | | | 1 | 1 | 5 | 1 | 2 | 1 | | | | | | | | | | | | | | | | | |
| **MACROPODIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Macropus robustus* | Euro | | | | | | | | | | | | | | | | | | | | 1 | | | | | | | | 10 | 2 |
| *Macropus rufus* | Red Kangaroo | | | | | | | | | | | | | | | | | | 2 | | | | | | | | | | 2 | |
| *Petrogale rothschildi* | Rothschilds Rock Wallaby | | | | | | | | | | | | | | | | | | | | | | | | | | | | 2 | 2 |
| **HIPPOSIDERIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Rhinonicteris aurantia* (Pilbara form) | Pilbara Leaf-nosed Bat | **VU** | **S1** | **VU** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **EMBALLONURIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Taphozous georgianus/hilli* | Common Sheathtail Bat | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Saccolaimus flaviventris* | Yellow-bellied Sheathtail Bat | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **VESPERTILIONIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Chalinolobus gouldii* | Gould's Wattled Bat | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Nyctophilus geoffroyi* | Lesser Long-eared Bat | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Scotorepens greyii* | Little Broad-nosed Bat | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Vespadelus finlaysoni* | Finlayson's Cave Bat | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **MOLOSSIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Chaerophon jobensis* | Northern Freetail Bat | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Mormopterus beccarii* | Beccari's Freetail Bat | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **MURIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Pseudomys chapmani* | Western Pebble-mound Mouse | | | **P4** | | | | | | | | | | | | | | | | | | | | | | | | | S | S |
| *Pseudomys delicatulus* | Delicate Mouse | | | | 1 | | | | | | | | | | 1 | | 1 | | | | | | 1 | | | | 2 | | | |
| *Pseudomys desertor* | Desert Mouse | | | | | 2 | | 1 | | 1 | | 5 | | 1 | | | 3 | | | | 2 | 9 | | 1 | 3 | 1 | | | | |
| *Pseudomys hermannsburgensis* | Sandy Inland Mouse | | | | 2 | | | 1 | 6 | 2 | | 1 | 11 | 7 | 8 | 3 | 5 | 4 | | 3 | 1 | | 6 | 2 | 6 | | 4 | | | 1 |
| *Zyzomys argurus* | Common Rock-rat | | | | | 1 | | 13 | | | | | 1 | 1 | 7 | 8 | | 1 | | 2 | 1 | 2 | | | | | 4 | 11 | | |
| **CANIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Canis lupus dingo* | Dingo | | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | 3 | 4 |
| **INTRODUCED MAMMALS** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Mus musculus* | House mouse | | | | 2 | | | | | | 1 | 1 | 1 | 6 | 1 | | 2 | 1 | | | 1 | 6 | 3 | | 5 | 5 | 5 | 1 | | |
| **Oryctolagus cuniculus* | Rabbit | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | 6 | 1 |

**Bat activity status:**

| | |
|---|---|
| | Low |
| | Medium |
| | High |

S = sign of activity

**Appendix E2: Birds site x species matrix**

| FAMILY and species | Common name | EPBC Act | WC Act | DEC | GWA s1 | | GWA s2 | | GWA s3 | | GWA s4 | | GWA s5 | | GWA s6 | | GWA s7 | | GWA s8 | | GWA s9 | | GWA s10 | | GWA s11 | | GWA s12 | | GWA Opp | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 |
| **PHASIANIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Coturnix ypsilophora* | Brown Quail | | | | | | | | 7 | | | | | | | | | | | | | | | | | | | | | |
| **COLUMBIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Phaps chalcoptera* | Common Bronzewing | | | | 4 | 1 | 2 | | | | | | 3 | | | | | | | 1 | | | | | | 3 | 4 | 1 | 14 | |
| *Ocyphaps lophotes* | Crested Pigeon | | | | | 7 | 1 | | 2 | 1 | 2 | 1 | | 2 | | | | 4 | 11 | 48 | 3 | 3 | | 2 | 24 | 4 | 4 | | | |
| *Geophaps plumifera* | Spinifex Pigeon | | | | | | | | | | | | | | | | | | | | | | | | | | | | 16 | 2 |
| *Geopelia cuneata* | Diamond Dove | | | | | | | | 23 | 2 | | | | | | | | | | | | 1 | 4 | | 2 | | | 2 | 19 | 2 |
| **PODARGIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Podargus strigoides* | Tawny Frogmouth | | | | 2 | | | | | | | | | | | | | | | | | | | | | | | | 5 | |
| **EUROSTOPODIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Eurostopodus argus* | Spotted Nightjar | | | | 1 | | 1 | | 1 | | 2 | | | | | | | | | | | | 1 | | | | | | | 3 |
| **AEGOTHELIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Aegotheles cristatus* | Australian Owlet-nightjar | | | | | | | | | | 1 | 1 | 1 | | | | | | | 1 | | | 1 | | | | | 1 | | 3 |
| **APODIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Apus pacificus* | Fork-tailed Swift | **M** | **S3** | | | | | | | 20 | | 70 | | | | | | 440 | | | | | | | | | | | | 23 |
| **THRESKIORNITHIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Threskiornis spinicollis* | Straw-necked Ibis | | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | |
| **ACCIPITRIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Elanus axillaris* | Black-shouldered Kite | | | | | | | | | | 1 | 1 | | | | | 1 | | | | 1 | | | | | | | | | 3 |
| *Haliastur sphenurus* | Whistling Kite | | | | | | | | 1 | | | | | | | | | | | 1 | | | | | | | | | | |
| *Accipiter fasciatus* | Brown Goshawk | | | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | |
| *Accipiter cirrocephalus* | Collared Sparrowhawk | | | | | | | | | | | | 1 | | | | | | | | | | | | 1 | | | | | |
| *Circus assimilis* | Spotted Harrier | | | | 3 | | | | 2 | 1 | | | 2 | | 3 | | | | 4 | 2 | | | 2 | | | | 1 | | 2 | 3 |
| *Aquila audax* | Wedge-tailed Eagle | | | | | | | | 1 | | | | | | | | | | | 1 | | | | | | | | | 1 | 1 |
| *Hieraaetus morphnoides* | Little Eagle | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | |
| **FALCONIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Falco cenchroides* | Nankeen Kestrel | | | | | | | | | | 1 | 1 | | | | | | 2 | | | | | | 1 | | | | | | |
| *Falco berigora* | Brown Falcon | | | | 1 | | | | | | 2 | | 1 | 1 | | | 2 | 1 | 2 | 1 | | | 2 | | 1 | | 1 | 1 | 6 | 7 |
| *Falco longipennis* | Australian Hobby | | | | | | | | 1 | | | | | | | | | | 1 | | | | | | | | | | | |
| **OTIDIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Ardeotis australis* | Australian Bustard | | | **P4** | | | | | | | | | | | | | | | | | | | | | | | | | 3 | |
| **BURHINIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Burhinus grallarius* | Bush Stone-curlew | | | **P4** | | | | | | S | | | | | | | | | | | | | | | | | | | | |
| **TURNICIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Turnix velox* | Little Button-quail | | | | | | 1 | | | | | | 5 | | 3 | | 2 | | 5 | 1 | | 1 | 10 | | 4 | | 6 | | 18 | 1 |
| **CACATUIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Eolophus roseicapillus* | Galah | | | | | | | | 13 | | 4 | 14 | | | | | | | 1 | 38 | | | 10 | | | | | | | |
| *Nymphicus hollandicus* | Cockatiel | | | | | | | | 35 | 10 | 1 | | | | | | | | | 66 | | | | | | 20 | | | | |
| *Barnardius zonarius* | Australian Ringneck | | | | 9 | 8 | | 6 | | | | 2 | 8 | | | 6 | 7 | | | | | 7 | 5 | | | 3 | | | 2 | |
| *Psephotus varius* | Mulga Parrot | | | | | | | | | | 8 | | | | | | | | | | | | | 2 | | | | | | |
| *Melopsittacus undulatus* | Budgerigar | | | | | | | | 65 | 10 | 64 | 8 | 31 | 4 | 76 | | 82 | 5 | 348 | | | 2 | 14 | | 141 | 30 | 9 | 14 | 95 | 12 |
| **CUCULIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Chalcites basalis* | Horsfield's Bronze-Cuckoo | | | | | | | | | | 1 | | | | | | | | | | | | 1 | | | | | | | |
| **STRIGIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Ninox novaeseelandiae* | Southern Boobook | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | |
| **TYTONIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Tyto javanica* | Eastern Barn Owl | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 |

**Appendix E2: Birds site x species matrix**

| FAMILY and species | Common name | EPBC Act | WC Act | DEC | GWA s1 | | GWA s2 | | GWA s3 | | GWA s4 | | GWA s5 | | GWA s6 | | GWA s7 | | GWA s8 | | GWA s9 | | GWA s10 | | GWA s11 | | GWA s12 | | GWA Opp | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 |
| **HALCYONIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Todiramphus pyrrhopygius* | Red-backed Kingfisher | | | | | | 1 | | | | 3 | | 1 | 1 | | | 1 | 1 | | | 1 | | 2 | | 1 | 2 | 2 | | 1 | |
| **PTILONORHYNCHIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Ptilonorhynchus guttatus* | Western Bowerbird | | | | | | | | | | 1 | 1 | | | | | | | | | 1 | | | | 2 | | | | 1 | 1 |
| **MALURIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Malurus splendens* | Splendid Fairy-wren | | | | | | | | 5 | 6 | | | | | | | | | | | | | | | | | | | | |
| *Malurus leucopterus* | White-winged Fairy-wren | | | | | | | | 2 | 2 | 3 | 9 | | | | | | | 18 | 10 | | | | | 5 | 2 | | | 5 | 4 |
| *Malurus lamberti* | Variegated Fairy-wren | | | | | 2 | 10 | 10 | | 6 | 9 | 14 | 4 | 7 | | | | | 4 | | 2 | 1 | 12 | 4 | 14 | 8 | | | 23 | 6 |
| *Stipiturus ruficeps* | Rufous-crowned Emu-wren | | | | | | | | | | | | | | | | 3 | 8 | | | | | | | 2 | 10 | 8 | 3 | | |
| **ACANTHIZIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Smicrornis brevirostris* | Weebill | | | | 46 | 42 | 37 | 30 | | | 17 | 19 | 11 | 32 | 7 | 11 | 9 | 5 | | | 27 | 22 | | 3 | | 7 | 31 | 18 | 30 | 7 |
| *Gerygone fusca* | Western Gerygone | | | | 1 | | 4 | | 20 | 10 | 4 | 1 | | | | | 3 | | | | | | 11 | 2 | 1 | | | | 7 | 2 |
| *Acanthiza uropygialis* | Chestnut-rumped Thornbill | | | | | | | | 37 | 11 | | | | | | | | | | | | | | | | | | | | 6 |
| *Acanthiza apicalis* | Inland Thornbill | | | | | 2 | 2 | | 12 | 7 | 1 | 1 | | | | | | 2 | | | | | 8 | 11 | | | | 6 | 7 | |
| **PARDALOTIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Pardalotus rubricatus* | Red-browed Pardalote | | | | | | | | | | | | | 2 | | 1 | 3 | | | | | 2 | | | | | | | 1 | |
| *Pardalotus striatus* | Striated Pardalote | | | | 4 | | 2 | | | | 5 | | | | | | | | | | 2 | 3 | | | | | | | 3 | |
| **MELIPHAGIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Lichenostomus virescens* | Singing Honeyeater | | | | 11 | 3 | | 3 | 2 | 7 | 13 | 30 | 11 | 15 | 6 | 10 | 16 | 20 | 11 | 31 | 5 | 7 | 5 | 11 | 13 | 28 | 6 | 2 | 13 | 9 |
| *Lichenostomus keartlandi* | Grey-headed Honeyeater | | | | 12 | 16 | | | | | 11 | 11 | 9 | | 7 | 2 | 9 | 2 | | | 23 | 20 | | | | | 4 | 1 | 7 | |
| *Purnella albifrons* | White-fronted Honeyeater | | | | | 1 | | | | | | 2 | | | | | | | | | | | | | | | | | | |
| *Manorina flavigula* | Yellow-throated Miner | | | | 23 | 22 | 8 | 15 | | 18 | 3 | 2 | 6 | 2 | | 6 | 7 | 6 | | | 9 | 2 | | 1 | | 8 | 5 | 1 | 7 | 1 |
| *Acanthagenys rufogularis* | Spiny-cheeked Honeyeater | | | | 14 | | 2 | | 11 | 21 | 8 | 3 | 2 | | | | 15 | | | | | | 2 | 6 | 2 | | 3 | | 5 | 2 |
| *Conopophila whitei* | Grey Honeyeater | | | | | | | | | 3 | | | | | | | | | | | | | | | | | | | | |
| *Epthianura tricolor* | Crimson Chat | | | | 4 | | | | | | 2 | | 3 | 7 | | | 12 | | | | 31 | | | | | | | | 11 | 3 |
| *Lichmera indistincta* | Brown Honeyeater | | | | 2 | 4 | 1 | 8 | | | | | | | | | | | | | | | | | | | | | | |
| *Melithreptus gularis* | Black-chinned Honeyeater | | | | | | | | | | | | | | | | 2 | | | | | 3 | | | | | | | | |
| **POMATOSTOMIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Pomatostomus temporalis* | Grey-crowned Babbler | | | | 3 | 6 | 6 | 12 | | 4 | 9 | 12 | | 2 | 4 | 5 | 9 | 12 | | | | 2 | | | 2 | | 7 | 4 | | 2 |
| *Pomatostomus superciliosus* | White-browed Babbler | | | | | | | | 7 | | | | | | | | | | | | | | | 4 | | | | | | |
| **CAMPEPHAGIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Coracina novaehollandiae* | Black-faced Cuckoo-shrike | | | | | | 1 | | 3 | 1 | | 2 | 4 | 3 | | 1 | 1 | | | | | 2 | 2 | | 1 | | 1 | | 1 | 2 |
| *Lalage sueurii* | White-winged Triller | | | | | | | | 2 | 7 | 10 | 1 | 2 | | | | | | | | 4 | | 1 | | 4 | | | | | |
| **PACHYCEPHALIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Pachycephala rufiventris* | Rufous Whistler | | | | 5 | 13 | 5 | 5 | 8 | 4 | 3 | 7 | 3 | | | | | 4 | | | 2 | 2 | 5 | 9 | 1 | | 2 | 3 | 5 | 3 |
| *Colluricincla harmonica* | Grey Shrike-thrush | | | | 2 | 11 | 1 | 2 | | 1 | 4 | 2 | 1 | 7 | | 3 | 3 | 4 | | | 3 | 5 | | 6 | 3 | | 1 | | 2 | |
| *Oreoica gutturalis* | Crested Bellbird | | | | | 5 | 1 | 5 | 1 | 6 | 2 | 19 | 2 | 5 | 1 | 2 | 3 | 9 | 1 | | 1 | 2 | 2 | 1 | 5 | 1 | 3 | 1 | 2 | |
| **ARTAMIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Artamus personatus* | Masked Woodswallow | | | | | | 25 | | | | | | | | | | | | | | | | | | 12 | | | | | |
| *Artamus cinereus* | Black-faced Woodswallow | | | | 8 | 3 | | | 10 | | 16 | 7 | 6 | 23 | | 12 | 11 | 6 | | 3 | 17 | 21 | 12 | 1 | 4 | 3 | | 5 | 12 | 2 |
| *Artamus minor* | Little Woodswallow | | | | 3 | | | | | | 1 | 6 | | | 5 | 24 | | | | | | 4 | | | | 5 | 2 | 6 | 4 |
| *Cracticus torquatus* | Grey Butcherbird | | | | 1 | 4 | 2 | 1 | 5 | 6 | 1 | 1 | | 1 | | | | 1 | | 1 | 1 | 1 | 5 | 3 | 1 | | 1 | 2 | | |
| *Cracticus nigrogularis* | Pied Butcherbird | | | | 5 | 7 | 2 | 4 | 3 | 4 | 1 | 6 | 1 | 1 | 1 | 2 | | 2 | | | 4 | 3 | | | | | | | | |
| *Cracticus tibicen* | Australian Magpie | | | | | 4 | 3 | | | | | 2 | | 1 | | | | | | | 1 | 2 | 1 | | | | | 3 | 2 |
| **RHIPIDURIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Rhipidura albiscapa* | Grey Fantail | | | | | | | | | | | | 1 | | | | | | | | | | 3 | | | | | | 2 | |
| *Rhipidura leucophrys* | Willie Wagtail | | | | | 6 | 1 | 4 | 4 | 6 | 7 | 11 | 3 | 6 | 5 | 5 | 6 | 12 | | | 11 | 7 | 5 | 8 | 4 | | 3 | 2 | 6 | 3 |

**Appendix E2: Birds site x species matrix**

| FAMILY and species | Common name | EPBC Act | WC Act | DEC | GWA s1 | | GWA s2 | | GWA s3 | | GWA s4 | | GWA s5 | | GWA s6 | | GWA s7 | | GWA s8 | | GWA s9 | | GWA s10 | | GWA s11 | | GWA s12 | | GWA Opp | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 |
| **CORVIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Corvus bennetti* | Little Crow | | | | 2 | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Corvus orru* | Torresian Crow | | | | | 2 | | | 2 | 2 | | 3 | 1 | 3 | | 2 | 3 | | 1 | 1 | | 1 | 1 | | | | 1 | 2 | | |
| **MONARCHIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Grallina cyanoleuca* | Magpie-lark | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | |
| **PETROICIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Petroica goodenovii* | Red-capped Robin | | | | 1 | 1 | | | 28 | 8 | | | | | | | | | | | | | 1 | 4 | | | | | | |
| *Melanodryas cucullata* | Hooded Robin | | | | | | 1 | | | 2 | 1 | 2 | | 3 | | | | 1 | 3 | 3 | 1 | | | 2 | 1 | | | | 2 | 1 |
| **ALAUDIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Mirafra javanica* | Horsfield's Bushlark | | | | | | | | | | | | | | | | | | 3 | | | | | | | | | | | |
| **MEGALURIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Cincloramphus mathewsi* | Rufous Songlark | | | | | | | | | | | 3 | | 4 | | | | | 3 | | 4 | 1 | | | | | | | 2 | 1 |
| *Cincloramphus cruralis* | Brown Songlark | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 |
| *Eremiornis carteri* | Spinifexbird | | | | | | | | | | 6 | 14 | 2 | 1 | 6 | 3 | 7 | 11 | | | 4 | 2 | 3 | 5 | 3 | 10 | 2 | 3 | 3 | |
| **NECTARINIIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Dicaeum hirundinaceum* | Mistletoebird | | | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | |
| **ESTRILDIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Taeniopygia guttata* | Zebra Finch | | | | 2 | | | 2 | 24 | 17 | 49 | 44 | 35 | 58 | 126 | 17 | 64 | 4 | 113 | 15 | 2 | 4 | 116 | 7 | 24 | 15 | 32 | 11 | 49 | 10 |
| *Emblema pictum* | Painted Finch | | | | | | | 8 | | | | 5 | | | 31 | 4 | | | | 2 | | 1 | | 2 | | | 20 | | 2 | |
| **MOTACILLIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Anthus novaeseelandiae* | Australasian Pipit | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | |

**Appendix E3: Reptiles site x species matrix**

| FAMILY and species | Common name | EPBC Act | WC Act | DEC | GWA s1 | | GWA s2 | | GWA s3 | | GWA s4 | | GWA s5 | | GWA s6 | | GWA s7 | | GWA s8 | | GWA s9 | | GWA s10 | | GWA s11 | | GWA s12 | | GWA Opp | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 |
| **AGAMIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Amphibolurus longirostris* | | | | | 3 | | | 3 | | | | | | | | | | | | | | | | 2 | 1 | | 1 | | 3 | 4 |
| *Ctenophorus caudicinctus* | Ring-tailed Dragon | | | | 7 | 2 | 1 | 2 | | 1 | 5 | 7 | 4 | 2 | 10 | 3 | 7 | 1 | 2 | | 5 | 1 | 3 | 8 | 6 | 3 | 1 | 1 | 13 | 26 |
| *Diporiphora valens* | | | | | | | | | | | | 1 | | | | | | | | | | | | | | | | | | |
| *Pogona minor* | Dwarf Bearded Dragon | | | | | | 9 | 1 | | 1 | | | | | | | | | | | 2 | | | | | 1 | | 1 | | 2 |
| *Tympanocryptis cephalus* | Pebble Dragon | | | | | | | | | | | | | | | | | | | 3 | | | | | | | | | | |
| **DIPLODACTYLIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Diplodactylus pulcher* | | | | | | | | | 3 | | 2 | | | | | | | | | | | | | 1 | | | | | | |
| *Diplodactylus savagei* | | | | | 2 | | 2 | | | | | | | | | | | | | | | | | | | | | | | |
| *Lucasium stenodactylum* | | | | | | 1 | 1 | | | | 5 | | | | | | 1 | 1 | | | 4 | 2 | | | 1 | 1 | | | 1 | |
| *Lucasium wombeyi* | | | | | 1 | | | 1 | | | | | | | | | | | | | 1 | 1 | | | | | | | 1 | |
| *Oedura marmorata* | Marbled Velvet Gecko | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 3 |
| *Rhynchoedura ornata* | Beaked Gecko | | | | | | | | 3 | | | | | | | | | | | | 2 | | | | | | | | | |
| *Strophurus wellingtonae* | | | | | 2 | | | | 2 | | 1 | 1 | | | | | | 2 | | | 12 | | 1 | 1 | | | | | | |
| *Strophurus elderi* | | | | | 2 | | | | | | | | | | | | | | | | | | | | | | | | | |
| **CARPHODACTYLIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Nephrurus wheeleri* | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | 1 | | |
| *Underwoodisaurus seorsus* | | | | **P1** | | 1 | | | | | | | | | | | | | | | | | | | | | | | | |
| **GEKKONIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Gehyra punctata* | | | | | | | | | | | | | | | 3 | | | | | | | | | | | | 1 | | 2 | |
| *Gehyra variegata* | | | | | 9 | 5 | 1 | 4 | 6 | 5 | | | 2 | 3 | | | | 2 | | | | 1 | 3 | 4 | 3 | 5 | 4 | 1 | 3 | |
| *Heteronotia binoei* | Bynoe's Gecko | | | | 1 | 6 | 1 | 3 | | | 2 | 6 | 2 | | 5 | 12 | 5 | 8 | | | | 1 | 2 | 7 | 1 | 2 | 1 | 7 | | |
| *Heteronotia spelea* | Desert Cave Gecko | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | 1 | | |
| **PYGOPODIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Delma elegans* | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | 1 | 1 | | |
| *Delma nasuta* | | | | | 1 | 1 | | | | | | | | | 1 | | 1 | | | | | | | | 1 | | | 2 | | |
| *Delma pax* | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | 1 | | | |
| *Delma tincta* | | | | | | | | | | | | | 1 | | | | | | | | 1 | | | | | | | | | |
| *Lialis burtonis* | | | | | | | | | | | | 1 | 1 | | | | | | | | | 1 | 1 | 1 | | 1 | | 1 | 1 | |
| *Pygopus nigriceps* | | | | | | | | | 1 | 5 | 1 | | | | | | 1 | 1 | | | 1 | 1 | | | | | | | | |
| **SCINCIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Carlia munda* | | | | | | 2 | 7 | 3 | | | | 4 | 1 | 1 | 1 | 1 | 4 | 1 | | 3 | 3 | 3 | 2 | 1 | 3 | 6 | 2 | | | |
| *Carlia triacantha* | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | |
| *Cryptoblepharus ustulatus* | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | 1 | | 2 | 17 |
| *Ctenotus duricola* | | | | | | 1 | 1 | | | 1 | | | 1 | 7 | 2 | 1 | 1 | | | | | 3 | 1 | | 2 | | | | | |
| *Ctenotus helenae* | | | | | 1 | 2 | 4 | 2 | | | 4 | 6 | 4 | 1 | 1 | 1 | 7 | 3 | | | 6 | 3 | 8 | 2 | 2 | | 7 | 4 | | |
| *Ctenotus pantherinus* | Leopard Ctenotus | | | | 4 | 2 | | | | | 6 | 3 | 7 | 5 | 8 | 1 | 13 | 6 | 5 | 7 | 10 | 3 | | 8 | 7 | 2 | 4 | 13 | | |
| *Ctenotus robustus* | | | | | | | | | | | | | | | | | | | | 4 | | | | | | | | | | |
| *Ctenotus rutilans* | | | | | | 1 | | | | | 2 | 2 | | 1 | | 1 | | | | | | | | 1 | 1 | | | | | |
| *Ctenotus saxatilis* | Rock Ctenotus | | | | 1 | 4 | | 5 | | 1 | | 1 | 1 | | 4 | 4 | | 1 | | 1 | 1 | 14 | 1 | 2 | | | 1 | 15 | | 4 |
| *Ctenotus schomburgkii* | | | | | | | | | 7 | 18 | | 2 | | | | | | | | | 3 | | | | | | | | | |
| *Cyclodomorphus melanops* | Slender Blue-tongue | | | | | | | 3 | | | | | | | | | 1 | 1 | | | | 1 | | | | | | | | |
| *Egernia cygnitos* | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | |
| *Egernia formosa* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 2 |
| *Lerista muelleri* | | | | | | | | 1 | | | | | | | | 1 | | | | | | | 1 | | | | | | | |
| *Lerista neander* | | | | | | | | | | | 1 | | | | | | 1 | | | | 1 | | | | | | | | | |
| *Lerista timida* | | | | | 1 | | 3 | | | | | | | | | | | | | | | | | | | | | | | |

**Appendix E3: Reptiles site x species matrix**

| FAMILY and species | Common name | EPBC Act | WC Act | DEC | GWA s1 | | GWA s2 | | GWA s3 | | GWA s4 | | GWA s5 | | GWA s6 | | GWA s7 | | GWA s8 | | GWA s9 | | GWA s10 | | GWA s11 | | GWA s12 | | GWA Opp | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 |
| *Lerista verhmens* | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Lerista zietzi* | | | | | | 1 | 1 | 1 | | | 1 | | | | | | | | | | | | | | | | | | 2 | 2 |
| *Menetia greyii* | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | |
| *Morethia ruficauda* | | | | | | | 3 | | | | | | | | | | | | | | 3 | 1 | | | 1 | | 1 | | 1 | |
| *Tiliqua multifasciata* | Central Blue-tongue | | | | | | | | | | | | | | | | | 1 | | 3 | | 2 | | | | 1 | | 1 | 1 | |
| **VARANIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Varanus acanthurus* | Spiny-tailed Monitor | | | | 1 | 1 | | | | | 1 | 1 | 1 | 2 | 3 | 8 | | | | | 6 | 5 | | | | | | 2 | | |
| *Varanus brevicauda* | Short-tailed Pygmy Monitor | | | | | | | | | | 3 | 1 | 1 | 2 | | 1 | | 1 | | | | | | 4 | | 1 | | | | |
| *Varanus bushi* | Pilbara Mulga Monitor | | | | | 1 | 1 | | | 1 | 2 | 2 | | | | | | | | | | | | 2 | | 1 | | | | |
| *Varanus giganteus* | Perentie | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | 2 |
| *Varanus panoptes* | Yellow-spotted Monitor | | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | 4 |
| *Varanus tristis* | Racehorse Monitor | | | | 1 | | 1 | | | 2 | | | | | | | | | | | | | | 3 | | 1 | | 1 | | 1 |
| **BOIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Antaresia perthensis* | Pygmy Python | | | | | | | 1 | | | | | | | 2 | | | | | | | | | | | | | | 1 | 1 |
| **ELAPIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Acanthophis wellsi* | Pilbara Death Adder | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | |
| *Brachyurophis approximans* | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | 1 | 1 | | |
| *Demansia psammophis* | Yellow-faced Whipsnake | | | | | | | | 1 | | | | | | | | | 1 | 1 | 1 | | 1 | 1 | | | | | | | |
| *Demansia rufescens* | Rufous Whipsnake | | | | | | 1 | | | | | | | | | 2 | | | | | | | | | | | 1 | | | |
| *Furina ornata* | Moon Snake | | | | | 1 | | | | | | | 1 | | | | 1 | | | | | | | | 2 | | 1 | 1 | 1 | 1 |
| *Parasuta monachus* | Hooded Snake | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | 2 |
| *Pseudechis australis* | Mulga Snake | | | | 1 | 1 | | 1 | | 1 | | | | | | | | 1 | | 1 | | | | | | | | | 3 | |
| *Pseudonaja mengdeni* | Western Brown Snake | | | | | | | | | | | 1 | | | | | | | | | | 3 | | | | | | | 2 | |
| *Pseudonaja modesta* | Ringed Brown Snake | | | | | | | | 1 | | | | | | | | | | | | | | | 2 | | | | | | |
| *Suta fasciata* | Rosen's Snake | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | 2 |
| *Vermicella snelli* | Pilbara Bandy Bandy | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | |

biologic

# West Angelas – Deposit B and F

# Ghost Bat Assessment

## Robe River Joint Venture

## March 2014



| DOCUMENT STATUS | | | | |
|---|---|---|---|---|
| Revision No. | Author | Review / Approved for Issue | Approved for Issue to | |
| | | | Name | Date |
| 1 | Tania Wild | Morgan O'Connell | Carly Nixon | March 2014 |

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## EXECUTIVE SUMMARY

Rio Tinto commissioned Biologic Environmental Survey Pty Ltd (Biologic) to undertake a survey of known Ghost Bat (*Macroderma gigas*) roost caves at its West Angelas Deposit B and F (hereafter referred to as the Study Area), which is located approximately 100 kilometres west north west of Newman in the Pilbara region of Western Australia. The caves are located adjacent to pits and associated mining infrastructure.

The Ghost Bat is listed as Conservation Priority 4 by the Western Australian Department of Parks and Wildlife (DPaW) and as Vulnerable by the International Union for the Conservation of Nature (IUCN). The presence of Ghost Bats has been known at West Angelas since at least 1979.

In 1997, as part of the West Angelas Iron Ore Proposal a Ghost Bat Management Plan was developed and a series of monitoring surveys was implemented between 1997 and 2003. Disturbance was not originally proposed for any of these caves during development of a mine at Deposit B; however the pit design was subsequently amended and extended northwards in closer vicinity to the caves.

The scope of the present assessment was to undertake a survey of known Ghost Bats roosts near Deposit B at West Angelas (caves A1, A2, L2 and L3) and at Deposit F (AA1) to determine presence and level of use and thus the conservation value of these caves to Ghost Bats. These caves are referred to as the 'monitoring caves.'

The caves at Deposit B had previously been surveyed by Biologic in November 2012. A second monitoring survey was conducted by Biologic between the 11th and 14th November 2013 by two experienced zoologists. The results from both these surveys are provided in this report.

The monitoring caves were searched for bats and their traces and SM2 bat detector was placed in each cave. Scat collection sheets and temperature/ relative humidity data loggers that were left in place during the 2012 survey were collected.

Ghost Bat usage was observed at four of the five monitoring caves; caves A1, A2 and AA1 had recent scats, and Ghost Bat calls were recorded from the mouth of caves A2 and L3. One Ghost Bat was recorded roosting at cave AA1 during the day. There was no indication that cave L2 had been used by Ghost Bats during the survey period or the prior 12 months.

Based on the results of the two monitoring surveys, it is considered that caves A2, L2 and L3 are used as feeding caves / night roosts. Cave A1 is considered to be a feeding/ day roost and possible maternity roost. Cave AA1 has historically been known to be used as a maternity roost.

The pattern of usage of these caves appears to be intermittent, although some caves (A1 and AA1) appear to be used more regularly than others. During the current survey, only AA1 was in use as a day roost. None of the caves adjacent to Deposit B were currently in use as maternity roosts, but occasional use for this purpose cannot be ruled out at A1. Caves A1 and AA1 have the size and complexity requirements for breeding use.

Given the small estimated size of the Ghost Bat population in the Hamersley Range, the unique genetic variations of these populations, and the bats apparent need to utilise a variety of caves at different times and for different purposes, every suitable roost cave is likely to be of importance to the population. None of the caves fall within the proposed pit area, but it is important to protect the cave site from damage and disturbance as a result of mining operations (i.e. blasting). However, even if the bats cease using the caves closest to the pit during the active life of the mine, it is likely that following closure of the mine and rehabilitation of the site, the caves will become available for use in the future.

The presence of a series of Ghost Bat roost caves with a long monitoring history at different distances from the proposed mine provides an ideal opportunity to study the effects of mining disturbance on Ghost Bats in a controlled manner. It is therefore recommended that annual monitoring surveys be continued and a monitoring and mitigation plan be developed prior to pit extension operations commencing.

# 1 INTRODUCTION

## 1.1 Project Background

Rio Tinto commissioned Biologic Environmental Survey Pty Ltd (Biologic) to undertake a monitoring survey of known Ghost Bat (*Macroderma gigas*) roosts near Deposit B and F at West Angelas hereafter referred to as the 'Study Area' (Figure 1.1). The Study Area is located approximately 100 kilometres (km) west north west of Newman, in the Pilbara region of Western Australia. Rio Tinto is proposing to develop the Deposit B pit, together with its associated waste dumps and infrastructure (Figure 1.2).

The Ghost Bat is listed as Priority 4 by the Western Australian Department of Parks and Wildlife (DPaW) and as Vulnerable by the International Union for the Conservation of Nature (IUCN) (see Appendix A for explanation of conservation codes).

Five caves have been identified for monitoring; caves A1, A2, L2 and L3 near Deposit B and cave AA1 near Deposit F. These caves are hereafter referred to as the 'monitoring caves.'

Four caves (caves A1, L2, L3 and I1) close to Deposit B have been previously identified as being of value to Ghost Bats (Ecologia, 1998b) and one near Deposit F (AA1) (Armstrong and Anstee 2000). Cave I1 could not be located during a reconnaissance survey by Biologic in October 2012, and no caves within 'Gully I' were considered to be suitable for Ghost Bats. This cave was subsequently removed from the monitoring programme. An additional cave, cave A2, located in close proximity to cave A1, was identified during the reconnaissance survey as being suitable for Ghost Bats, and hence was included in the monitoring survey.

Disturbance was not proposed in the Environmental Review and Management Programme (ERMP) (submitted to the Environmental Protection Authority (EPA) in 1998 (ecologia Environmental Consultants, 1998a)) for any of the original four monitoring caves. However the Deposit B pit design was subsequently altered and extended northwards. It was considered possible that any Ghost Bats present in the caves near Deposit

B may be disturbed by indirect impacts such as noise or vibration from mining activities.

In light of the new extended pit plans at Deposit B, Biologic was commissioned to undertake monitoring of Ghost Bat presence at the five monitoring caves. A survey was undertaken in November 2012 and demonstrated that there was evidence of recent use of the caves (i.e. 'fresh' scats) and/or signs of historic occupation (i.e. guano accumulations that do not contain 'fresh' material). This survey was conducted during the known Ghost Bat breeding season in an attempt to determine if the caves were being used as maternity roosts, and hence the conservation value of these caves could be determined.

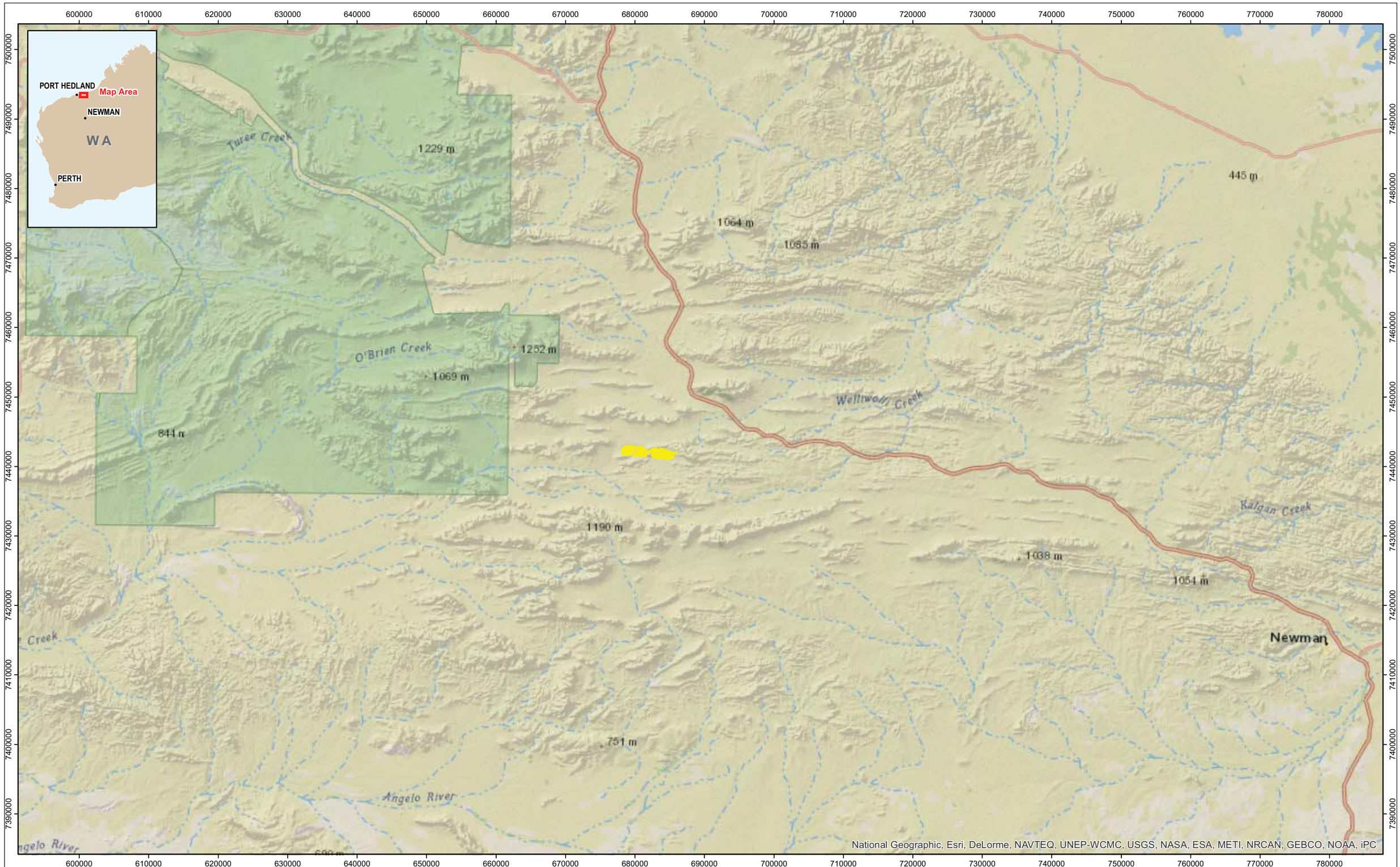
The November 2012 survey identified a pattern of intermittent use of the monitoring caves by Ghost Bats, which was consistent with results from previous monitoring surveys undertaken between 1997 and 2003 (Ecologia 1998a, 1998b, 2000 and 2001, Biota Environmental Services, 2002, 2004b).

## 1.2 Scope of Works

Biologic were commissioned by Rio Tinto to undertake a survey of five monitoring caves at West Angelas. The main aims of the survey were:

- Review records of historical surveys in the region and other relevant literature to determine the likelihood of use and the conservation significance of caves at West Angelas;
- Undertake a survey of five monitoring caves near Deposit B and Deposit F to determine presence of Ghost Bats or recent use; and
- Determine the importance of each cave for local Ghost Bat populations (i.e. night roost, day roost and/or maternity roost).

This report provides results from surveys undertaken in November 2012 and November 2013.




600000 610000 620000 630000 640000 650000 660000 670000 680000 690000 700000 710000 720000 730000 740000 750000 760000 770000 780000

7500000 7490000 7480000 7470000 7460000 7450000 7440000 7430000 7420000 7410000 7400000 7390000

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|---|---|---|---|
| **FIGURE 1.1** | | Date: | 04/01/2013 |
| Sheet Size: | A3 | Status: | FINAL |
| Drawn by GSM | Requested by D.G | GSM Reference RTIO_WA_Regional_location | |

N

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Kilometers

1:500,000

Datum: GDA94

Projection: MGA Zone 50

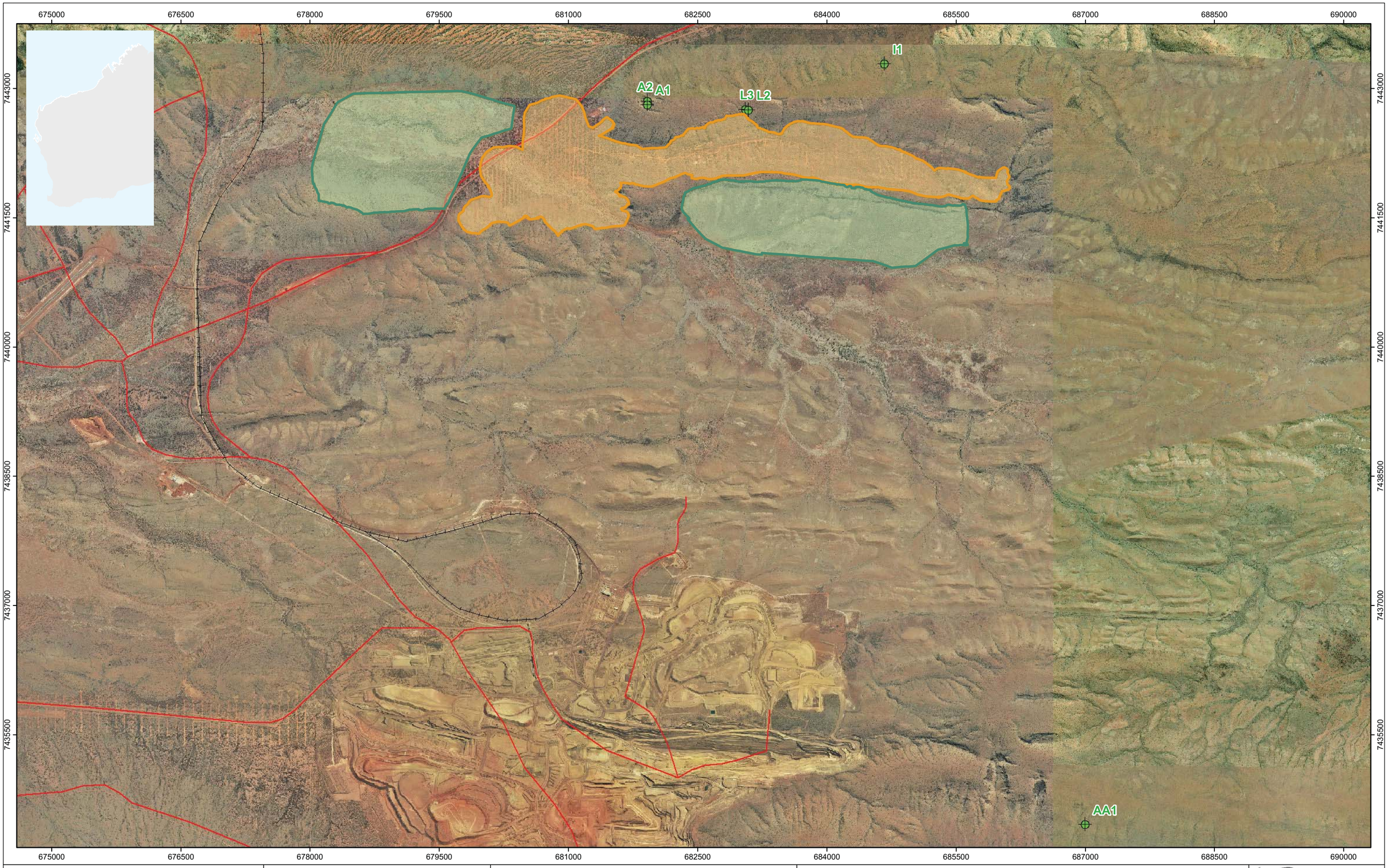
# RTIO

**WEST ANGELAS DEPOSIT B**
**REGIONAL LOCATION**
**FIGURE 1.1**

**Legend**

Study Location

GRIFFIN SPATIAL & MAPPING
PO Box 7215
Eaton WA 6232
admin@griffinspatial.com.au
+61 8 9725 3213




biologic

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|---|---|---|---|
| **FIGURE 1.2** | | Date: | 17/03/2014 |
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| Drawn by GSM | Requested by TW | GSM Reference RTIO_WA_Cave_location | |

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Meters

1:40,000

Datum: GDA94

Projection: MGA Zone 50

# RTIO

## WEST ANGELAS DEPOSIT B LOCATION OF CAVES A1, A2, L2, L3, I1 AND AA1

**Legend**

- Cave Locations
- Deposit B Dumps
- Deposit B Pit

GRIFFIN SPATIAL & MAPPING
PO Box 7215
Eaton WA 6232
admin@griffinspatial.com.au
+61 8 9725 3213

# 2 EXISTING ENVIRONMENT

## 2.1 Biogeography

Broadly, the Study Area falls within the Pilbara biogeographical region as defined by the Interim Biogeographic Regionalisation of Australia (Thackway and Creswell, 1995). The Pilbara is subdivided into four subregions. The Study Area lies in the Hamersley subregion (PIL-3), which falls in the southern section of the Pilbara Craton (Kendrick, 2001). The subregion is characterised by mountainous areas of Proterozoic sedimentary ranges and plateaux, dissected by gorges (Kendrick 2001).

## 2.2 Geology

The Study Area and its surroundings are underlain by bedrock of Archaean and Proterozoic age, belonging to the Hamersley Basin, consisting mainly of Banded Iron Formation, chert and shale (Tyler *et al.*, 1991). The two larger ore bodies (Deposits A and B) at West Angelas occur within the Marra Mamba Iron Formation, in association with synclinal structures on the banks of the Wanna Munna anticline plunging to the west.

The higher ground is part of a remnant plateau, the Hamersley Surface, of late Mesozoic to early Tertiary age, characterised by lateritic and other ferruginous deposits. The lower ground is occupied by Cainozoic valley-fill deposits of alluvium and colluvium, which may be up to 100 m thick. Older valley-fill deposits are generally consolidated and commonly cemented by iron oxides, being enriched to ore grade in places.

## 2.3 Land Forms

The Study Area consists of a rounded east-west strike ridge rising about 100 m above the valley, and formed from the Marra Mamba Iron Formation. The slopes of the ridge are incised with steep V-shaped valleys and gorges, which tend to end in horseshoe-shaped gullies below a capping sedimentary outcrop. Cave formation occurred beneath this outcrop. This is well exhibited in gullies ‘A’ and ‘L’ which contain caves used by Ghost Bats.

## 2.4 Vegetation

Vegetation mapping of the Pilbara region was completed on a broad scale (1:1,000,000) by Beard (1975). The Study Area is situated in the Hamersley Plateau in the Eremaean Botanical Province of Western Australia as per Beard (1975) who broadly mapped the area as ranges and valley plains.

The vegetation of the Study Area is dominated by scattered Snappy Gum (*Eucalyptus leucophloia*) over spinifex hummock grassland (predominantly *Triodia brizoides*) on skeletal soils on the ranges, while between them are swathes of mulga (*Acacia aneura*) low woodland over bunch grasses on fine-textured soils of the valley floors (Kendrick, 2001).

## 2.5 Climate

The Pilbara region has a semi-desert to tropical climate with highly variable, mostly summer rainfall. The average annual rainfall over the broader Pilbara area ranges from about 200 – 350 millimetres (mm) (predominantly in January, February and March), although rainfall may vary widely from year to year. The Pilbara climate is heavily influenced by tropical cyclones that develop over the Indian Ocean in the north of Australia. These sometimes cross the northwest coastline, bringing heavy rainfall to inland regions of the Pilbara.

The Newman airport (109 km ESE of the Study Area) and Paraburdoo airport (106 km W of the Study Area) weather stations are located closest to the Study Area and provide an indication of temperature and rainfall patterns in the area.). Average annual rainfall and average monthly maximum temperatures are shown in Table 2.1 (BoM 2014).

**Table 2.1:** Average weather conditions at the Newman and Paraburdoo Airport weather stations (BoM 2014).

| Weather station location | Average Annual rainfall (mm) | Average monthly max temperature (°C) |
|---|---|---|
| Newman airport | 310.2 mm (max in Feb 80.1 mm) | 31.4 °C (max 39 °C Jan) |
| Paraburdoo airport | 283.8 mm (max in Feb 56.1 mm) | 33.3°C (max 40.8 °C Jan) |

## 2.6 Hydrology

Rainfall occurs mainly as tropical summer storms, therefore monthly and annual totals vary widely (see Figure 2.2). Watercourses flow only after heavy or prolonged rainfall, as short-duration floods with rapid peaks and slightly less rapid decline. Water may pond along major watercourses, and persists as pools for several weeks or months. There are few permanent pools or springs in this region of the Pilbara.

The Study Area falls within the Ashburton River catchment. Weeli Wolli Creek is located to the east of the Study Area.

# 3 LITERATURE REVIEW

## 3.1 Ecology and Demography

The Ghost Bat is a large carnivorous bat, weighing 140-165 g (Richards *et al.*, 2008), having a diet of small terrestrial mammals, amphibians, small birds, other bats, lizards, spiders and large insects. Ghost Bats hunt using their excellent vision as well as detecting audible sounds and ultrasonic echoes. The Ghost Bat's foraging strategy and high trophic niche, as a top nocturnal carnivorous predator, is unique in Australian microbats (Churchill, 2008; Richards *et al.*, 2008).

The Pilbara Ghost Bat population is estimated at 1500-2000 based on recently published estimates (approximately 600, N.L. McKenzie pers. comm.; approximately 1000, (Armstrong and Anstee 2000); and "more common than previously supposed", McKenzie and Bullen 2009). These recent data (estimates less than 15 years old) come from surveys throughout the general Pilbara area; however these data are limited to surveys undertaken for mining companies (and therefore contain a bias towards areas of potential ore reserves) and the Pilbara Biological Survey undertaken by the DPaW. A majority of this work relied upon echolocation detectors, which are not considered to be as reliable as visual cave assessments (i.e. the presence of scats within caves can be determined even if bats aren't present at the time of survey, but bat detectors would give presence data only if bats were present at the time of survey). Moreover some bat detector technologies are not always reliable for detection of this species as Ghost Bats occasionally use audible social calls instead of ultrasound. Current population estimates in the Hamersley and Chichester subregions are approximately 300 and 1500 respectively (Mr Robert Bullen, *unpub. data*); however further detailed surveys would be required to validate these estimates.

Ghost Bat breeding populations are currently known from a small number of maternity roosts in the Pilbara. The largest of these are in abandoned mines in the Chichester subregion and number up to several hundred (Armstrong and Anstee 2000). There is no known large, permanent

maternity roost in the Hamersley subregion. Known Hamersley populations are between five and 50 individuals in local groups (Bat Call WA, *unpub. data*).

The Ghost Bat is known to disperse from maternity sites on an annual cycle depending upon seasonal weather conditions and availability of suitable day roosts (Richards *et al.*, 2008). The Ghost Bat uses three types of roost regularly, these being (i) night or feeding roosts, (ii) day roosts and (iii) maternity roosts.

(i) Feeding roosts are only used at night, either habitually or for transitory visits. They are typically shallow caves and shelters/ overhangs that can be well lit during the day. They are often high in the strata and are poorly protected from the elements. They contain guano pile(s) and midden(s) (middens differ from scat piles in that they are extensive in size; the width is typically 500 mm or larger, and contains food remains in the form of feathers and bones) of various sizes.

(ii) Day roosts include caves and mine adits that are deeper and more complex in structure. They typically have one or more large chambers at or beyond the twilight area with additional fissures or chambers at the rear in the fully dark regions. They have a minimum roof height in the chambers of two to three metres providing protection from attack by terrestrial predators. Day roosts are often lower in the strata and are well-insulated overhead providing a stable temperature environment. They typically contain multiple middens of guano and food remains that include feathers and skeletal material.

(iii) Maternity roosts are day roosts that provide additional features that are able to support a reproducing population. These features are both natural high temperature (over 27 °C) and humidity levels greater than 75 % relative humidity, or an interior chamber that is rising toward the rear thereby trapping warmer and more humid air at the top, allowing these conditions to form during the period when reproductive females and pups are present. These

roosts are considered regionally significant. It is important to note however that the temperature and humidity characteristics of maternity caves are drawn from caves outside of the Hamersley Range. Recent surveys in the Hamersley Range have recorded breeding in caves that are seemingly less favourable (M O'Connell, pers. obs. 2012).

For aggregations of Ghost Bats to persist in an area, the bats usually require a range of night and day roosting opportunities; at least one deep cave with characteristics of a maternity roost, a productive set of gullies and gorges locally (typically within 1 km) and a productive foraging area within a 5-10 km radius, which usually includes a good quality riparian area, and appropriate protection from human interference (Mr Robert Bullen, pers. comm.). Ghost Bats are known to reproduce in years with high food availability (generally coinciding with above average, prolonged or successive wet seasons) using suitable natural day and maternity roost caves (an example from the Hamersley subregion is a small group of individuals including reproducing females, from caves in the Nammuldi/ Silvergrass area (Hamersley Iron, 1999)).

## 3.2 Conservation Status

The Ghost Bat has a conservation status of Priority 4 (taxa in need of monitoring) as listed by the DPaW in both the Pilbara and Kimberley. It is Vulnerable C1 (a vulnerable species numbering less than 10,000 and in decline) under the International Union for Conservation (IUCN) Red List (IUCN 2011).

The IUCN (2011) describes its listing as Vulnerable based on the following:

- the species has a small population (less than 10,000 mature individuals);
- the inferred decline in the last three generations has been greater than 10 %, and there is the potential for the population to decline even faster within the next three generations; and

- populations of the species are fragmented, but not considered to be severely fragmented - other than within the Queensland part of the range - as there is likely to be interchange among colonies within, though not between, other parts of the range.

The DPaW do not provide a justification for the Priority 4 listing; however it is likely attributed to the limited roosting habitat available in the Pilbara, and much of this habitat is under threat by mining activities.

## 3.3 Threats

Numerous surveys have been undertaken over recent years by government departments, universities and research centres, mining companies and environmental consultants in an effort to understand the biological communities present in the region and the effect of changes on the biodiversity (such as development of mining, introduction of feral animals and weeds, changing fire regimes and increased human population) of the region. This has resulted in an increase in the amount of data on species occurrences and distributions.

Currently the main threats to this species in the Pilbara are disturbances associated with mining and entanglement in barbed wire fences (Armstrong and Anstee 2000). The threats to Ghosts Bats in mining areas include direct loss of habitat, disturbances to roosts due to drilling and mining, abandoned mine collapse, human disturbance, competition with introduced predators and foraging habitat modification (Hall *et al.* 1997; Duncan *et al.* 1999).

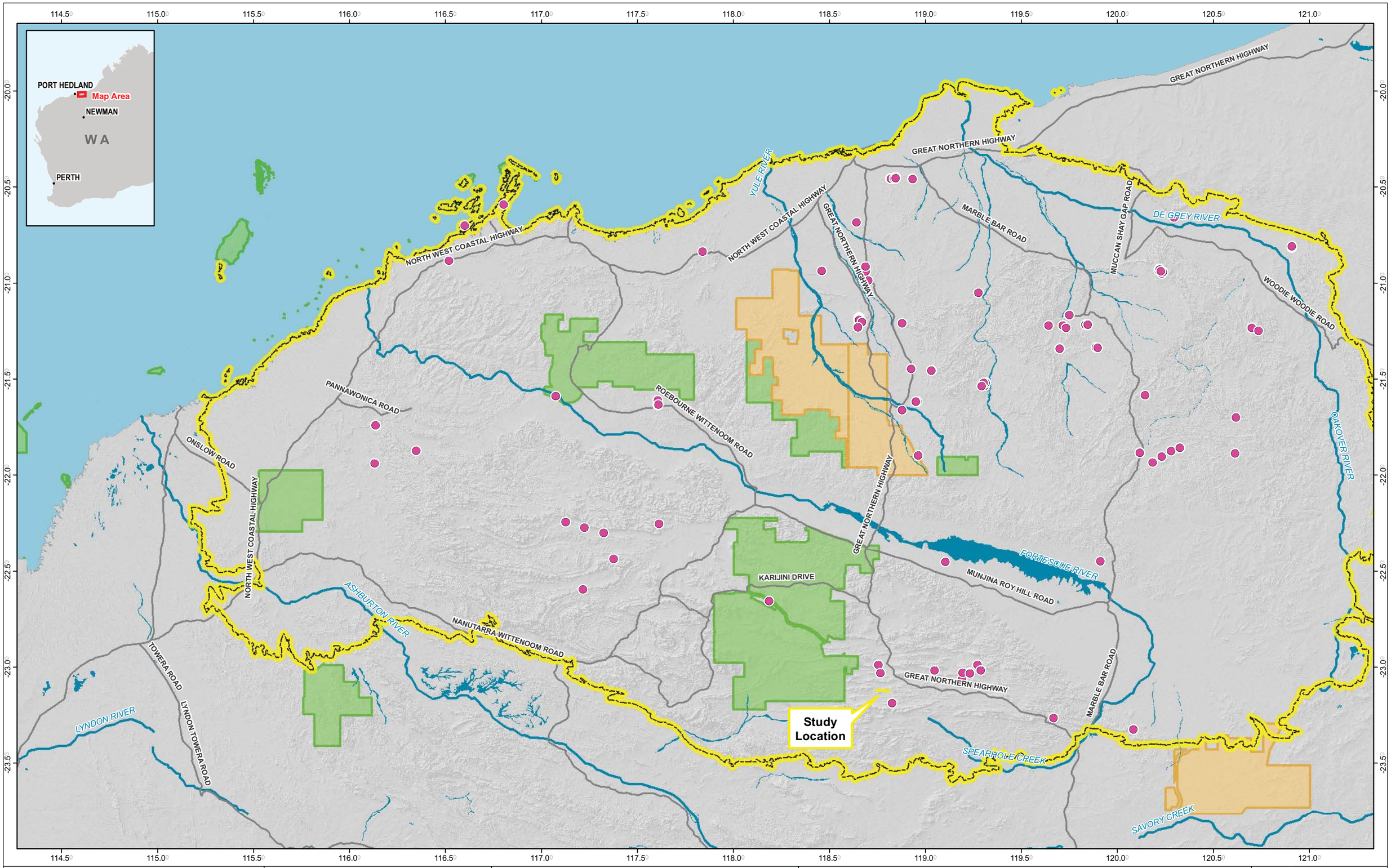
In the context of the current study, the main threats to Ghost Bats using caves located in close proximity to active mining operations (particularly caves L2 and L3) include vibration (potentially resulting in cave collapse or areas of cave collapse rendering them unsuitable for Ghost Bat usage) and increased dust levels (reducing the quality of foraging habitat in the vicinity of the caves) as a result of blasting activities at the nearby Deposit B pit.

## 3.4 Publicly Available Records

All publicly available records of Ghost Bats from the Pilbara bioregion were compiled using the NatureMap database (Department of Parks and Wildlife (previously Environment and Conservation) and the Western Australian Museum, 2012) and from other records available to Biologic. The distribution of Ghost Bats in the Pilbara is illustrated in Figure 3.1. This indicates that although Ghost Bats are distributed widely across the Pilbara bioregion, the distribution is patchy and sparse. There are fewer records from the Hamersley Range than the Chichester region, in agreement with available population estimates.

Genetic studies indicate that there is a major division between the Hamersley Ghost Bat populations and those from eastern Pilbara (Chichester) Ghost Bats, with the Fortescue valley acting as a barrier to the flow of mtDNA (female philopatry) (Biota Environmental Services, 2004a). Moreover, the Hamersley populations have a higher degree of unique genetic diversity, while the eastern Chichester populations have a lower diversity of haplotypes consistent with recent derivation of the populations through the founder effect. This may result from recent colonisation of abandoned mines in the Chichester area (Biota Environmental Services, 2004a).

The relatively small population size and genetic uniqueness both serve to increase the importance of the Hamersley Ghost Bat populations in term of their conservation.




biologic

| | | | |
|---|---|---|---|
| **FIGURE 3.1** | | Date: | 10/01/2013 |
| Sheet Size: | A3 | Status: | FINAL |
| Drawn by GSM | Requested by D.G | GSM Reference RTIO_WA_Regional_location | |

N

0 20 40 60 80 100

Kilometers

1:2,000,000

Datum: GDA94

Projection: MGA Zone 50

# RTIO

## GHOST BAT RECORDS LOCATED IN THE PILBARA BIO-REGION FIGURE 3.1

**Legend**

- Ghost Bat Records
- Pilbara IBRA 61 Boundary
- Study Location

**Reserves**

- IndigenousReserve
- NatureConservationReserve

- Roads
- Hydrology
- Lakes

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PO Box 7215
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## 3.5 Summary of Previous Bat Monitoring at West Angelas

The first sightings of Ghost Bats in the proximity of West Angelas were documented in 1978 (Integrated Environmental Services, 1980). Ghost Bats have been recorded in the West Angelas area, at various levels of intensity, at least six times since they were first reported. A summary of previous Ghost Bat monitoring at West Angelas has been prepared (Nixon, 2012). This is presented in Appendix B and salient points from this are extracted in Table 2 below.

**Table 3.5:** Summary of Ghost Bat monitoring at West Angelas from 1979 – 2012.

| Survey | Summary |
|---|---|
| An ecological appreciation of the West Angelas environment, Western Australia 1979 (Integrated Environmental Services, 1980) | Results of an extensive fauna and flora survey conducted between 1978 -1979. Ghost Bats were reported from a cave near Deposit E (Cave 1) and presence at two further caves, including one near Deposit B (Cave 3). Caves 1 and 3 were considered to be maternity roosts on the basis of their large middens and the presence of a possibly pregnant female, captured at Cave 1. [Note that Cave 1 appears to be Cave AA1 and the coordinates given for Cave 3, although erroneous, place this cave in the vicinity of the Deposit B Cave A1 of ecologia Environmental Consultants (1998c) and later reports] |
| West Angelas Iron Ore Project Vertebrate Fauna Assessment Survey (ecologia Environmental Consultants, 1998b) | An extensive vertebrate fauna assessment was undertaken by Ecologia Environmental Consultants between June and October 1997. Four Ghost Bats were recorded in rocky gully habitat (sites WA4, WA12 and WA13) in the mine area including a cave near Deposit B. Eight Ghost Bats were observed roosting in a cave overlooking the Mulga plains in the Coondewanna West section of the rail corridor. These records confirmed earlier reports of Ghost Bat presence at West Angelas (Integrated Environmental Services, 1979). |
| West Angelas Project Ghost Bat (*Macroderma gigas*) Assessment *Survey (ecologia Environmental Consultants,* | A systematic survey of gullies adjacent to Deposits A, B, E and F was undertaken between August and September 1998. This survey sought to clarify the distribution and abundance of Ghost Bats at West Angelas, as recommended by the West Angelas ERMP to minimise the potential impacts on Ghost Bats.<br>A total of 60 caves in 27 gullies were searched for Ghost Bats, scat material and animal remains. Many |

| Survey | Summary |
|---|---|
| *1998c)* | cave-like structures were found; however not all were regarded as suitable roosts for bats. Bats were only found in caves, none were found in overhangs or other geomorphological features.<br>One female Ghost Bat was captured in a very large cave (AA1) near Deposit F. It was a mature female and may have been pregnant as its abdomen was swollen. The abundance of scats and feeding remains in the AA1 cave suggested long term utilisation. The cave was thought to be a Ghost Bat maternity cave and was considered to be of considerable conservation significance. Although only one Ghost Bat was observed during the survey, a total of six caves and an adit contained evidence of Ghost Bat use. The condition of scat material in the other five caves and the adit suggested all had been used relatively recently, at least within the last year. It appeared that these caves were subject to only temporary, intermittent or seasonal use. Caves with only small amounts of Ghost Bat scat material and feeding remains were thought to be used as feeding sites only (A1, L2, I1, AB1 and the adit). |
| West Angelas Minesite Ghost Bat Assessment Survey, September 2000. (ecologia Environmental Consultants, 2000) | A survey was undertaken during August 2000 for evidence of Ghost Bats in caves previously surveyed to clarify the distribution and abundance of Ghost Bats in the proposed project area. Many cave-like structures were present in the survey area however not all were regarded as suitable roosts for bats. Of the five caves surveyed, recent evidence of Ghost Bats was recorded in two of the caves (I1 and AA1) and a Ghost Bat was sighted in cave A1. Caves L2 and L3 showed signs that Ghost Bats had been habituating these caves in the past, but it was difficult to evaluate how long ago this occurred. |
| West Angelas Minesite Ghost Bat Monitoring Survey, September 2001. (ecologia Environmental Consultants, 2001) | A survey of caves identified as supporting Ghost Bats during the September 2000 survey was undertaken during September 2001. Bat occupation was based on the presence of scats and condition of scat material. Of the five caves known to contain evidence of Ghost Bats, recent activity was recorded at only three caves. Evidence collected in two of the caves (AA1 and A1) comprised bone fragments and scats. In the third cave (AB1) only scats were collected. No Ghost Bats were found roosting in any cave searched during the 2001 survey. |
| Ghost Bats at West Angelas: 2002 | All seven Ghost Bat roosts identified previously were examined for current or recent signs of occupancy. The additional caves mentioned in Ecologia (2001) |

| Survey | Summary |
|---|---|
| Survey, Data Review and Future Directions. (Biota Environmental Services, 2002) | were not examined as these did not contain evidence of past use by Ghost Bats. No Ghost Bats were observed in any feature. Recent signs of occupancy ('fresh' scats) were present in three caves (AA1, AB1 and L3) and the West Angelas adit. The remainder of the caves (A1, I1 and L2) showed no signs of recent activity. Very little obvious feeding remains were observed in any cave. |
| Monitoring of Ghost Bat Roosts at West Angelas 2003 (Biota Environmental Services, 2004b) | All seven Ghost Bat roosts (six caves and one adit) identified previously from West Angelas were examined for recent signs of occupancy in December 2003. Ghost Bats were observed in cave A1 adjacent to Deposit B. Recent signs of occupancy (non-degraded scat material) were present in two other caves (AA1 and AB1) indicating that they may have been used by a small number of individuals at most sometime during the year. The West Angelas adit and the remainder of the caves (I1, L2 and L3) showed no signs of recent activity. Very little obvious feeding remains were observed in any cave. |
| West Angelas – Deposit B Ghost Bat Assessment (Biologic 2012) | Four caves identified as in close proximity to the new pit designed for Deposit B were surveyed for bats and their traces in October 2012. Caves A1 and L3 were also surveyed using passive ultrasound survey. The results of the current study concur with those of previous surveys in that the pattern of usage of these caves is intermittent. Presence of Ghost Bat usage of caves A1 and L3 was confirmed by the presence of a significant quantity of recent scats, and by Ghost Bat calls recorded on two nights outside cave L3. However no Ghost Bats were recorded roosting in these caves during the day. These two caves were categorised as feeding/ night roosts and occasional day roosts. The size and complexity of these caves, together with the quantities of scats, suggests use as occasional maternity roosts cannot be ruled out. |

# 4 METHODS

## 4.1 Survey Team

The assessment was undertaken by ecologists with extensive experience with the target bat species in the Pilbara. The following personnel were involved in the project:

- Mr Morgan O'Connell – Principal Zoologist. Project Manager and quality assurance.
- Dr Drew Gardner – Senior Zoologist. Field survey and reporting.
- Mr Thomas Rasmussen – Senior Zoologist. Field survey.
- Dr Tania Wild – Senior Environmental Advisor. Reporting.
- Mr Robert Bullen – Specialist Bat Consultant (subcontracted from Bat Call WA). Analysis of bat calls.

Assistance in the field was given by Rio Tinto personnel.

## 4.2 Field Survey

### 4.2.1 Timing

The field survey was conducted from the 11th to 14th November 2013. The survey was timed to coincide with the breeding season of Ghost Bats (see Section 3).

### 4.2.2 Weather

Temperatures at Newman airport (BOM station 007176, 109 km ESE of the Study Area) during the survey ranged between 17.5 ºC and 40.6 ºC, which fall within the typical temperature range for November. Relative humidity ranged between 1 % and 15 % which was low compared to the average relative humidity for November (15 % to 23 %). In November 2013, the total monthly rainfall was 7.4 mm, which was slightly lower than the monthly average (9.8 mm) (BoM 2014).

Temperatures at Paraburdoo airport (BOM station 007185, 106 km W of the Study Area) during the survey ranged between 20.9 ºC and 41.2 ºC, which fall within the typical temperature range for November. Relative

humidity ranged between 6 % and 15 %, which was low compared to the average relative humidity for November (11 % to 23 %). The total monthly rainfall for November 2013 was 0.8 mm, which was lower than the monthly average (6.4 mm) (BoM 2014).

#### 4.2.3 Cave Assessment

The caves were categorised using the following definitions:

- **Feeding Cave / Night Roost** - no individuals seen and only a small number of scats observed.
- **Feeding Cave / Possible Day Roost** –no individuals seen but large scat piles observed.
- **Day Roost** - individuals are or have been observed within the cave during the day. The cave can be visually inspected for the presence of juveniles, and a negative result is obtained.
- **Day Roost / Possible Maternity Roost** - individuals are observed within a cave during the day but flush or hide before a full inspection of individuals possibly carrying juveniles can be made.
- **Maternity Roost** - juveniles are observed attached to females within a cave.

Note that all maternity roosts are day roosts, but not all day roosts are maternity roosts.

At the mouth of each cave a team of two observers documented cave morphology and geology. Assessments on cave stability were undertaken to determine if caves were safe to enter. Readings of gas concentrations (oxygen, carbon dioxide, hydrogen sulphide and the lower explosive limit) in the cave atmosphere, as measured inside the cave mouth, were taken by Rio Tinto personnel using a calibrated hand-held gas meter. If deemed safe, the lead observer entered the caves for a more detailed visual assessment and the second observer remained outside the cave entrance to watch for Ghost Bats departing the cave during the assessment. Radio and vocal communications were maintained between the observers at all times.

The dimensions of each cave were measured using a laser distance measure and measurements of relative humidity, temperature and light levels were made both at the cave entrance and at the roost site inside the cave.

The use of the cave by Ghost Bats was confirmed by a visual sighting and/ or the presence of middens and/ or scat piles within the cave. The Ghost Bat is distinctive in being very much larger than any other cave dwelling bat in the region, and is easily identified. Scats and middens are also distinctive for this species. Any individuals sighted were assessed to determine the reproductive status (i.e. if juveniles were present or if females were gravid).

Sheets of black cotton measuring 1.5 $m^2$ were placed on any middens or large scat piles present to collect any scats dropped between the present and any subsequent surveys. Presence of scats on the sheets indicates use of the caves by Ghost Bats over a known time period, and enables acquisition of scat samples for further studies (e.g. dietary analysis).

#### 4.2.4 Remote Detection

Ultrasonic bat detectors (SM2 Songmeter, Wildlife Acoustics USA) recording continuously (Hyder *et al.* 2010) were placed in the entrance of all five caves for two nights (12 and 13 November 2013), to determine if Ghost Bats or other bat species were present. The SM2 Songmeters contain omnidirectional microphones and record calls in .wav high quality audio formats, compressed to form .wac files. The SM2 Songmeter also records audible calls, which are often made by Ghost Bats when exiting caves, thus providing an additional method of detecting this species.

# 5 RESULTS

## 5.1 2013 Survey

Evidence of Ghost Bat usage was observed at four (AA1, A1, A2 and L3) of the five monitoring caves:.

- Cave AA1: one Ghost Bat was observed in cave during the day on 14th November 2013 and fresh scat piles were present.
- Cave A1: fresh scat piles were present.
- Cave A2: fresh scats and Ghost Bat calls recorded on 12th November.
- Cave L3: Ghost Bat calls were recorded on the 12th November. No scats observed.

Gas measurements for all caves were within normal atmospheric levels.

Two other bat species were recorded during the survey, *Vespadelus finlaysoni* and *Taphozous georgianus.*

## 5.2 Comparison with Previous Surveys

Monitoring of bat caves has been undertaken at West Angelas since 1978, with nine surveys undertaken over the 25 year period. Eight caves have been assessed during these surveys (Table 5.1).

During a reconnaissance survey by Biologic in October 2012, cave I1 could not be located, and an additional cave (A2) was included in the monitoring programme. On recommendation of Rio Tinto, cave AB1 and the adit were not included in the programme. Cave AB1 is considered unlikely to be impacted by mining operations, and this, along with the adit, was considered by ecologia (1998) to be a night (feeding) roost only.

Cave A1, AA1, AB1, I1, L3 and the Adit have shown signs of Ghost Bat use during all surveys they have been assessed; however the level of use has varied (although it is noted that this may be due to different survey techniques or experience of the consultants). Cave L2 is the only cave which has indicated no use of Ghost Bats during a survey period (this survey and November 2002 (Biota 2002)). Cave A2 has only been

monitored over the past two years, but during both surveys has shown presence of Ghost Bat surveys either during the survey or recently prior.

Note that the use of SM2Bat detectors has only occurred in the last two surveys. Anabat detectors have not been used in the monitoring programme.

**Table 5.1** Summary of Ghost Bat records from current and previous surveys.

| Cave | 1978/ 9 | 1997 | Sep 1998 | Aug 2000 | Sep 2001 | Nov 2002 | Dec 2003 | Nov 2012 | Nov 2013 |
|---|---|---|---|---|---|---|---|---|---|
| A1 | - | P(4) | R | P(1) | R | O | P(1) | R | R |
| A2 | - | - | - | - | - | - | - | R | R,C |
| AA1 | **P(1)** | - | **P(1)** | R | R | R | R | - | P(1), R |
| AB1 | - | P(8) | R | - | O | R | R | - | - |
| I1 | - | - | R | R | - | O | O | - | - |
| L2 | - | - | R | O | - | N | O | O | N |
| L3 | P | - | O | O | - | R | O | R, C | C |
| Adit | - | - | O | - | - | O | O | - | - |
| Ref | IES 1980 | Ecologia 1998a | Ecologia 1998b | Ecologia 2000 | Ecologia 2001 | Biota 2002 | Biota 2004 | Biologic 2012 | This report |

Note Caves AA1, AB1 are not in the vicinity of Deposit B. The Adit is due to be destroyed by the development of Deposit B, but was not included in the current survey.

P Ghost bats present (number observed in parentheses). Individuals considered possibly pregnant are shown in bold
R Recent signs of occupation from fresh scats
C Calls recorded at night (note that this was only undertaken in the most recent surveys)
O Guano accumulation but no fresh scats
N No signs of Ghost Bat occupation
- Not surveyed

## 5.3 Cave descriptions

### 5.3.1 Cave A1

Cave A1 is a large cave located at 681914mE 744280mS (WGS84). The cave is approximately 21 m deep and is situated mid-slope at the head of a horseshoe-shaped valley. The cave is reached via a vegetated talus slope from the valley floor. The entrance (Appendix B, Plate 1) faces NW, measures about 5 m across and 3.5 m high at the highest point, and is partially blocked by fallen boulders. It was not possible to reach the furthest

end of the cave as it became too narrow. The cave has one long chamber and a small side chamber on the right facing inwards. A low wall of fallen blocks 2-3 tiers high appears to have been constructed across the cave approximately 8 m in, separating the cave entrance area from the inner chamber (Plate 1). The outer chamber had a temperature of 28 °C, 25 %RH and 3000 lux. Conditions in the inner chamber were not able to be recorded.

Throughout the duration of the survey program (1997-2013), this cave appears to be consistently utilized by Ghost Bats. Surveys from 1997 to 2003 recorded the presence of Ghost Bats or recent signs of occupation in the cave. During the 2012 survey, the cave was found to contain abundant (1000+) Ghost Bat scats, including recent ones. There was also a scat pillar approximately 40 cm tall towards the rear of the cave.

In the current survey recent, fresh Ghost Bat scats (200 – 300) were found in the cave. The presence of Ghost Bat scats indicates use of the cave at least as a night feeding roost; however previous surveys have recorded animals using this as a day roost. No Ghost Bats were visually observed or recorded on ultrasonic recorders during the 2013 survey.

This cave is classified as a feeding / day roost cave and possible maternity roost. There was no indication that the cave was being used as a maternity roost during the November 2012 or November 2013 surveys; however one animal was recorded during December 2003, which is when roosts may be used for breeding.

### 5.3.2 Cave A2

This cave, located at 681918mE 7442857mS (WGS84), occurs mid slope on the northern side of gorge ‘A’ and faces south west (Plate 4). It extends for 14.8 m in a single chamber and has an entrance 4.5 m wide by 4 m high.

This cave has only been surveyed twice (2012 and 2013). During the 2012 survey, two recent Ghost Bat scats were found in the inner cave. In the 2013 survey, recent, fresh Ghost Bat scats (6-20) were also found in the cave. Ghost Bat calls were detected on the 12$^{th}$ November 2013, however

no individuals were observed. The consistent presence of small numbers of Ghost Bat scats indicates that at a minimum this cave is used as a night feeding roost. Further monitoring surveys may show it is used occasionally as a day roost.

### 5.3.3 Cave AA1

This cave, located at 686950mE 7434465mS (WGS84), extends for 70 m and has three chambers. The sheltered horizontal entrance is 15 m wide by 4 m high. The outer chamber had a temperature of 36 °C, 19 %RH and 4500 lux. The inner chamber had a temperature of 29.7 °C, 21 %RH and 0.00 lux.

This cave has been identified as an important maternity cave in the region, with the presence of a possibly pregnant female has recorded during 1978/9 (IES 1980) and September 1998 (ecologia, 1998b).

The cave has shown consistent presence of Ghost Bats during all surveys since monitoring commenced in 1978/9 (it wasn't surveyed during 2012). Ghost Bats have been observed in the cave on three occasions over the monitoring period (1978/9, 1998, 2013). Recent signs of occupation (scats) have also been consistently recorded (2000, 2001, 2002, 2003 and 2013).

During the current study, abundant, recent, fresh, old and ancient Ghost Bat scats were found in the cave. No Ghost Bat calls were recorded at this cave, however one Ghost Bat was recorded using the cave as a day roost. This bat was flushed from the roost, so an assessment of breeding status could not be made.

This cave is classified as a day roost, and maternity roost.

### 5.3.4 Cave L2

Cave L2, located at 683086mE 7442760mS (WGS84), has a single west-facing entrance sloping downwards from a pile of boulders from an old roof collapse. The entrance measures 5 m wide by 2.7 m high and the cave extends 25 m in a single chamber (Plate 5).

The outer chamber had a temperature of 34 °C, 24 %RH and 4000 lux. The inner end of the chamber was 33 °C, 24 %RH and 1.8 lux (light level equivalent to a moonlit night).

Recent Ghost Bat scats were recorded at this cave during the 1998 survey, however subsequent surveys have only recorded guano accumulation (2000, 2003 and 2012 surveys) or no signs of Ghost Bat occupation (2002 and this survey).

Although the cave appears to be suitable for Ghost Bat utilisation, it is possible that the downwards sloping entrance may deter them by making the exit more strenuous and difficult. The cave was therefore classified as a feeding/ night roost.

### 5.3.5 Cave L3

This cave is located at 683054mE 7442766mS, WGS84, extends for 29 m and has two chambers. The entrance is 12.5 m wide and 2.5 m high at the central point (Plate 8. Safe entrance is on the right hand side.

The outer chamber had a temperature of 32 °C, 26 %RH and 3800 lux. The inner chamber was 29 °C, 31 %RH and 0.15 lux. It appears to be less stable in terms of relative humidity than A1 with greater fluctuations (Figure 5.1). The inner chamber is in almost complete darkness.

This cave appears to have consistently supported Ghost Bats since monitoring commenced in 1978/9. Signs of Ghost Bat use (guano or scats) were recorded in 1998, 2000, 2002, 2003 and 2012. Ghost Bat calls were recorded during 2012 and 2013.

This cave is classified as a feeding/ night roost.

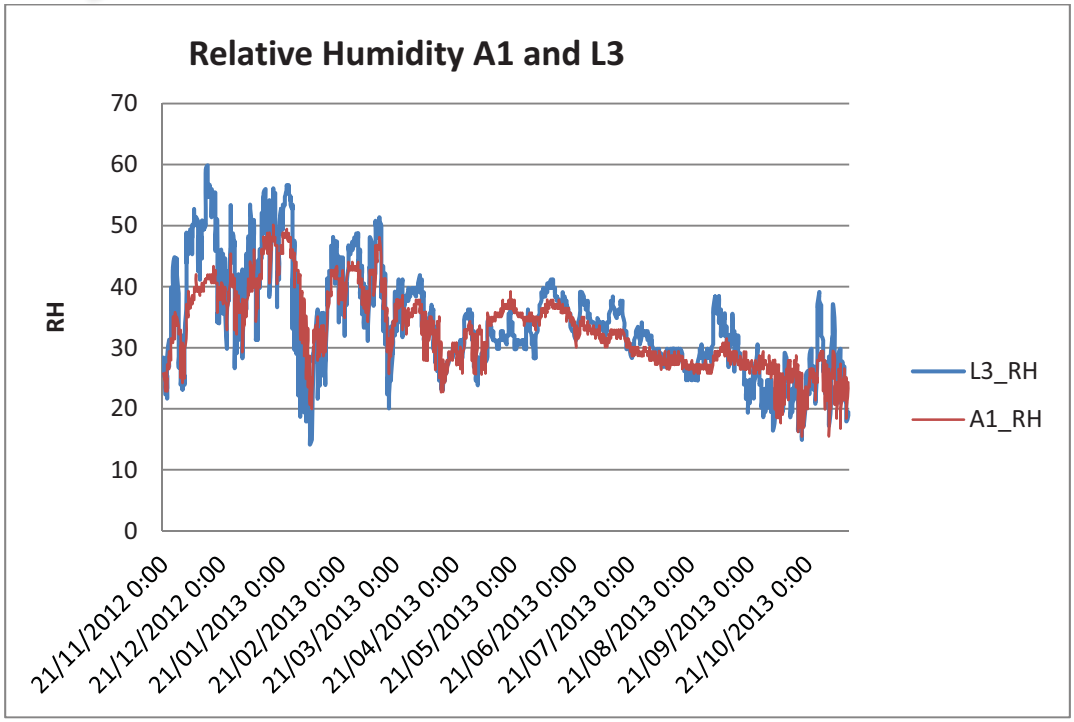
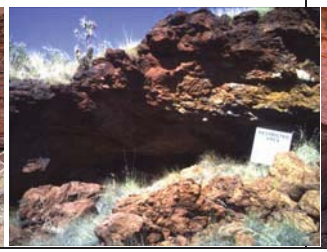



**Figure 5.1: Comparison of relative humidity between A1 and L3 from November 2012 to October 2013.**

## Table 5-2 Characteristics of Ghost Bat caves surveyed in November 2013.

| Cave | A1 | A2 | AA1 | L2 | L3 |
|---|---|---|---|---|---|
| Observed Ghost Bat usage | Ghost Bat scats (fresh, recent) | Ghost Bat scats (fresh, recent) | Abundant (2 x 1000+) Ghost Bat scats (fresh, recent, old and ancient) one with pillar. | No Ghost Bat scat seen. | No Ghost Bat scats seen. |
| Coordinates UTM Zone 50K, WGS84 | 681914mE 7442820mS | 681918mE 7442857mS | 686950mE 7434465mS | 683086mE 7442760mS | 683054mE 7442766mS |
| Basic Geology | Marra Mamba Iron formation | Marra Mamba Iron formation | Marra Mamba Iron formation | Marra Mamba Iron formation | Marra Mamba Iron formation |
| Entrance description | Single horizontal entrance at head of horseshoe-shaped gully | Single horizontal entrance on north side of horseshoe shaped gully | Entrance is open, wide but fairly low and horizontal in aspect. | Single entrance sloping down from boulders from old roof collapse. | Single horizontal entrance at head of horseshoe shaped gully |
| Entrance dimensions W x H (m) | 5 m X 3.2 m | 4.5 m X 4 m | 15 m x 4 m | 5 m X 2.7 m | 12 m x 2.5 m |
| Cave depth | 21 m | 14.8 m | 70 m | 25 m | 29 m |
| Entrance collapsed, tight or open | Open | Open | Open | Collapsed | Open |
| Entrance orientation | NW | WSW | W | W | S |
| Cave grouping | Loose group of caves and overhangs | Loose group of caves and overhangs | Unknown | Tight group of three caves in gully | Tight group of three caves in gully |
| Location on slope | Mid slope | Mid slope | Mid slope | Mid slope | Mid slope |
| Cave interior description | One long chamber with small side chamber | One chamber | Three chambers | One long chamber | One long chamber with smaller side chamber |
| Rear passages that may have Ghost Bat roosts | Yes | No | Yes | No | Yes |

| Cave | A1 | A2 | AA1 | L2 | L3 |
|---|---|---|---|---|---|
| Distance from proposed mining operations | 440 m | 470 m | 900+ m | 75 m | 67 m |
| Local Ghost Bat foraging opportunities | Eucalypt woodland and ephemeral pools in gorge gully. | Eucalypt woodland and ephemeral pools in gorge gully. | | Eucalypt woodland and ephemeral pools in gorge gully. | Eucalypt woodland and ephemeral pools in gorge gully. |
| Entrance chamber temperature, relative humidity and light level | 28 °C<br>25 %<br>3000 lux | 28 °C<br>25 %<br>3000 lux | 36 °C<br>19 %<br>4500 lux | 34 °C<br>24 %<br>4000 lux | 32 °C<br>26 %<br>3800 lux |
| Internal temperature, relative humidity and light level | - | - | 29.7 °C<br>21 %<br>0.00 lux | 33 °C<br>24 %<br>1.8 lux | 29 °C<br>31 %<br>0.15 lux |
| Type of Ghost Bat roost assessed | Feeding cave / day roost<br>Possible maternity roost | Feeding cave / night roost | Feeding cave/ day roost<br>/maternity roost | Feeding cave / night roost | Feeding cave/ night roost |
| Other bats present | *Vespadelus finlaysoni* | *Vespadelus finlaysoni*<br>*Taphozous georgianus* | *Taphozous georgianus* | *Vespadelus finlaysoni* | *Taphozous georgianus,* |
| | | | | | |
| Notes | Cave contained three sheets, however one sheet had been disturbed and could not be used. The other two sheets had an estimated 200-300 Ghost Bat scats. | No sheets present. Estimated 6-20 fresh/ recent Ghost Bat scats in cave.<br>Ghost bat calls detected on 12th November. | Numerous large scat piles (2 x 100+) and 2-3 areas of 100's scats.<br>Ghost bat flushed from the cave when entering on 14th November.<br>Cave was not suitable for video monitoring as the entrance was so wide. | No Ghost Bat scat seen. | No Ghost Bat scats on three sheets. Some *T. georgianus* scats. |

| Cave | A1 | A2 | AA1 | L2 | L3 |
|---|---|---|---|---|---|
| Photo |  |  |  |  |  |

## 5.4 Survey Limitations

The survey team was adequately experienced and resourced to achieve the project scope. The field survey was undertaken by two Senior Zoologists (Tom Rasmussen and Drew Gardner), both with extensive experience undertaking bat surveys. The same field team was used during the 2012 and 2013 surveys to provide a consistent approach to data collection and interpretation.

The survey intensity was appropriate for the scope and was conducted during the appropriate season to record breeding.

Previous Ghost Bat presence data from a number of sources were available prior to the study, including the previous monitoring reports at West Angelas. Availability of contextual information of the target species' ecology in the Pilbara is limited. Much of the ecological knowledge is inferred from the tropical forms. While this published knowledge was used to complement the field experience of the senior members of the team, all had adequate previous experience with the target species in the Pilbara. Data availability therefore is not considered a limitation to this survey.

Assessing the type of use by, and importance of caves to, Ghost Bats is extremely difficult, even for experienced zoologists. Bats are shy and cryptic, and generally roost in areas of the cave inaccessible to people. The survey techniques used for the monitoring are best practice, taking into account the survey outcomes and animal ethics. Mist netting or harp trapping can be use to catch animals exiting caves, but this is considered extremely stressful to the animals, particularly during the breeding season. Additional survey techniques that could be used to improve the outcomes of the monitoring are discussed in Section 6.

# 6 DISCUSSION

As Ghost Bats appear to utilise a variety of different caves at different times of the day and year and for different purposes, every suitable roost cave must be considered of some importance to this species. The November 2013 survey confirmed the importance of the Study Area for foraging and roosting Ghost Bats during the breeding season. Evidence of Ghost Bat usage was found in four of the five caves surveyed (caves A1, A2, AA1 and L3).

The impact of existing and future mining operations in the vicinity of the caves is of potential significance to local Ghost Bat populations and it is appropriate that monitoring is undertaken to understand these impacts. Caves L2 (75 m from pit wall) and L3 (67 m from pit wall) are in closest proximity to the Deposit B pit and therefore most likely to be impacted by mining activities.

Ghost Bat presence has been consistently recorded at cave L3 since the survey program began in 1978. It is classified as a feeding cave/ night roost cave; however, the size and complexity of this cave suggest that it could be utilised as a possible day roost. The importance of night roosts for Ghost Bats shouldn't be downplayed. Ghost Bats require a number of roosts within their home range. They provide shelter and rest to the bats whilst out foraging, and although removal of these roosts would not impact on the bats to the extent that removal of a day roost would, they still are of value to the Ghost Bat population. Cave L3 is oriented away from the pit wall so this may provide some level of protection from dust entering the cave. Its close proximity to the pit however may make it subject to collapse (or partial collapse) due to vibrations from blasting and/or heavy machinery.

Cave L2 is classified as a feeding/ night roost. There was no indication that this cave was used during the survey, or during the months preceding it. This cave has the lowest conservation value of all the caves in the monitoring programme.

There are insufficient data to determine if mining at West Angelas has affected use of these caves by Ghost Bats (i.e. if they were previously used as day roosts but are now used as night roosts); however these caves have consistently shown low levels of use since they were first surveyed during 1998 (cave L2) and 2000 (L3) and there has been no change in the patterns of use since they have been monitored.

Caves A1 and A2 are located in a gully approximately 400-500 m north of the Deposit B pit boundary. Cave A1 has been surveyed for Ghost Bats from 1997 to present and has consistently shown evidence of Ghost Bat use. Cave A2 has only been monitored during the past two years, but during both surveys has shown presence of recent and continual use. Both caves are classified as day roosts, and are therefore of significance to the local Ghost Bat population. There is currently insufficient data to determine if they are being used as maternity roosts, but this is considered possible. The monitoring results to date suggest that currently mining at West Angelas isn't impacting these caves.

Cave AA1 is considered to have the highest value of all the monitoring caves. During two surveys (1978/9 and 1998 a female was captured that was considered to be possibly pregnant. These caves are also shown to be consistently used by Ghost Bats as day roosts. Cave AA1 is located 900+ m from the pit boundary and should remain unaffected by mining activities (such as vibrations or dust).

Given the likely impact on caves within the Study Area, particularly those in closest proximity to the pit wall (L2 and L3), it is recommended that a monitoring and mitigation plan be developed to be implemented during and continue after the completion of mining operations at the Deposit B pit. The plan should consider, but not be limited to the following.

- Continue to monitor usage of the monitoring caves for changes in Ghost Bat use during and after the completion of mining operations. This will provide useful information regarding the impact of vibration on Ghost Bat activity and ultimately whether caves L2 and L3 will be used as day roosts following the completion of operations.

- Monitor dust levels and employ dust suppression techniques to minimise the impact of dust on foraging habitat. High dust levels reduce the quality of the nearby Ghost Bat foraging habitat, forcing the species to travel further to find more suitable grounds.
- Undertake blasting as far from the caves as possible. Various blasting patterns and types should be investigated and those with minimal potential impact employed.
- Check caves for structural integrity prior to, throughout and at the completion of the blasting operations. If caves appear unstable and the likelihood of collapse is high, install exclusion sheeting across the caves entrance so that no Ghost Bats are inside during blasting. Sheeting must be in place two hours after sunset to ensure that all bats have left the cave and that none are able to return. Sheeting can be removed once the risk of collapse has passed.

As previous noted (Biologic 2012), the significance of the Deposit B caves to the Pilbara populations of Ghost Bats is difficult to determine. However given the estimated small size of the Hamersley Range Ghost Bat population (Mr Robert Bullen, *unpub. data*), the genetic uniqueness of this population (Biota Environmental Services, 2004a), and the bats apparent need to utilise a variety of caves at different times and for different purposes, every suitable roost cave must be of some importance to the population. None of the caves fall within the proposed pit area, but it is important to protect the cave sites from indirect disturbance. Continued, consistent and informative monitoring of Ghost Bat numbers in the vicinity of the pit area will contribute to the understanding of cave usage by Ghost Bats in the area, their tolerance to disturbance associated with mining operations and resilience following disturbance.

Determining if caves are used as maternity roosts is extremely difficult, even if the bats are in the hand. During 2014/ 2015 Biologic will be undertaking research to see if juvenile bats emit different calls to adults, and this can be then used to see if caves are used as maternity roosts. Undertaking surveys during the dry season/ winter may also be useful to determine the value of caves. Caves used during this time would have the

least variation in temperature and humidity, and provide a warm environment.

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# APPENDICES

## Appendix A: Explanation of Conservation Codes

### *International Union for Conservation of Nature*

| Category | Definition |
|---|---|
| **Extinct (Ex)** | A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), and throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form. |
| **Extinct in the Wild (EW)** | A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range. A taxon is presumed Extinct in the Wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), and throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form. |
| **Critically Endangered (CE)** | A taxon is Critically Endangered when the best available evidence indicates that it meets any of the criteria A to E for Critically Endangered, and it is therefore considered to be facing an extremely high risk of extinction in the wild. |
| **Endangered (EN)** | A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered, and it is therefore considered to be facing a very high risk of extinction in the wild. |
| **Vulnerable (VU)** | A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable and it is therefore considered to be facing a high risk of extinction in the wild. |
| **Near Threatened** | A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future |
| **Data Deficient** | A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate. It is important to make positive use of whatever data are available. In many cases great care should be exercised in choosing between DD and a threatened status. If the range of a taxon is suspected to be relatively circumscribed, and a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified. |

### *Department of Environment and Conservation Priority Fauna Codes*

| Category | Definition |
|---|---|
| **Priority 1 (P1)** | Taxa with few, poorly known populations on threatened lands. |
| **Priority 2 (P2)** | Taxa with few, poorly known populations on conservation lands; or taxa with several, poorly known populations not on conservation lands. |
| **Priority 3 (P3)** | Taxa with several, poorly known populations, some on conservation lands. |
| **Priority 4 (P4)** | Taxa in need of monitoring. Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could be if present circumstances change. |
| **Priority 5 (P5)** | Taxa in need of monitoring. Taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years. |

## Appendix B: Photographs of monitoring caves



Plate 1 Cave A1 entrance



Plate 2 Cave A1 showing low wall across cave



Plate 3  Cave A1, inner cave with scat pile and scat collection sheets



Plate 4 Cave A2  Entrance



Plate 5 Cave L2, looking down entrance talus slope



Plate 6 View across gully ‘L’ from L2 towards L1 (left) and L3 (upper right)



Plate 7 Cave L3 entrance



Plate 8 Cave L3 inner chamber showing new scat sheets and old plastic

sheeting



Plate 9 Cave L3. Domed roof of inner chamber showing i-button datalogger (arrowed) placed on ledge.

# Appendix C Review of Bat Monitoring at West Angelas

Rio Tinto

# West Angelas Operations

## Environmental Management Program

Robe River Mining Co. Pty. Ltd.

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**Last updated:**

**September 2014**

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# 1 INTRODUCTION

## 1.1 OVERVIEW OF WEST ANGELAS

West Angelas Iron Ore Mine is located approximately 130 kilometres (km) northwest of Newman in the Pilbara region of Western Australia (Figure 1).

Robe River Mining Co. Pty. Ltd. (hereafter **Robe**), a wholly owned subsidiary of Rio Tinto, is the authorised manager of the West Angelas Iron Ore Mine on behalf of the Robe River Joint Venture Participants.

Production commenced in 2001 at Deposit A and in 2011 at Deposit E. Deposit A provides the primary ore source with Deposit E supplementing the production to maintain the current production rate. Deposit B is the next major ore source with mining scheduled to commence in 2015. Deposit A west and Deposit F have been identified as the next to be developed with mining scheduled to commence in 2016. The spatial configuration of the deposits within the context of the current mining operations is shown in Figure 2.

The integrated West Angelas Iron Ore Mining Operation (**WAO**) as implemented consists of:

- Open cut mining of iron ore from above and below the water table (**AWT** and **BWT**) by conventional drill, blast, load and haul techniques. Three deposits have been approved for mining (Deposits A, B and E). Production commenced in 2001 at Deposit A and in 2011 at Deposit E. Mining is scheduled to commence at Deposit B in 2015. Mining is scheduled to commence at Deposits A west and F from 2016.
- Ore processing in central processing facilities at a current rate of approximately 35 Million tonnes per annum (**Mtpa**).
- Surface waste dumps which will be used in progressive backfilling of the mine pits as far as practicable.
- A mine dewatering borefield which dewaters the ore bodies to allow mining BWT. Dewatering water is used on-site in the first instance to supply water for operational purposes (processing and dust suppression)
- The Turee Creek B Borefield, located approximately 30 km west of the mine site, which is used to provide potable water to the mine and camp facilities and, when required, water for processing purposes and dust suppression. The Turee Creek “B” Borefield Pipeline Corridor links the Turee Creek “B” Borefield with the West Angelas Minesite.
- An accommodation village which is located approximately 9 km west of the mine site.
- A mine access road which is approximately 35 km long and links the mine site with the Great Northern Highway. The intersection of the Great Northern Highway and the Mine Access Road is approximately 100 km northwest of Newman.
- A railway network which transports processed ore approximately 413 km to port facilities located at Cape Lambert and Dampier. The majority of the rail network is double track with spur lines to connect remote sites.

## 1.2 ENVIRONMENTAL APPROVALS

The West Angelas Project, which included Deposits A and B, was referred to the Environmental Protection Authority (**EPA**) under Part IV of the *Environmental Protection Act 1986* (**EP Act**) in May 1997 and was assessed at the level of Environmental Review and Management Program (**ERMP**). The ERMP was submitted to the EPA for assessment in March 1998. The EPA published its Report and Recommendations (Bulletin 924) on 30 January 1999 and the Minister for the Environment approved implementation of the West Angelas Project, subject to the conditions of Ministerial Statement 514 (**MS 514**), on 28 June 1999. Four subsequent project modifications were approved under section 45C of the EP Act.

Mining at Deposit E was granted *Not Assessed* by the Minister for the Environment on 21 June 2010. Additionally, discharge of excess dewatering water to the natural environment was granted *Not Assessed* by the Minister for the Environment on 20 December 2010.

Ministerial Statement 970 (**MS 970**), which completely supersedes MS 514, was approved on 11 June 2014. MS 970 currently provides a regulatory framework for environmental management across the entire West Angelas operations.

Robe is also committed to compliance with all relevant Federal, State and Local regulatory requirements. All relevant documentation including approvals, licences and permits will be made available to site personnel through the Health, Safety, Environment and Quality (**HSEQ**) website.

# 2 FRAMEWORK

## 2.1 PURPOSE

Condition 4 of MS 514 mandated that Robe prepare and implement an Environmental Management Program (**EMP**) which shall include a series of Environmental Management Plans. The management plans were approved by the CEO of the Department of Parks and Wildlife (**DPaW**, formerly the Department of Environmental Protection) in December 1999 and implemented from 2000.

Condition 5 of MS 970 requires the Proponent to 'implement the proposal in accordance with the *"Environmental Management Program"*, dated November 2013, or subsequent revisions approved by the CEO the Office of the Environmental Protection Authority'.

This updated EMP was prepared to address the requirements of MS 970 and supersedes all previous Environmental Management Plans.

This EMP specifically addresses:

- environmental aspects to be managed;
- environmental management objectives and targets and performance indicators;
- actions to manage environmental risks to prevent, minimise and mitigate potential environmental impacts;
- monitoring and reporting procedures; and
- details the timing and persons responsible for implementation of actions.

## 2.2 SCOPE

The key environmental factors considered by the EPA for the current mining operations are the:

- protection of vegetation associations having conservation value;
- protection of Declared Rare and Priority flora;
- protection of Specially Protected (Threatened) fauna;
- protection of subterranean fauna habitat;
- maintenance and restoration of original drainage patterns;
- protection of surface water and groundwater quality;
- protection of the values of Karijini National Park.

In response to these factors, the following environmental management plans have been developed:

1. Groundwater Management Plan (Section 4.1);
2. Surface Water Management Plan (Section 4.2);
3. Vegetation and Flora Management Plan (Section 4.3);
4. Fauna Management Plan (Section 4.4);

5. Dust Management Plan (Section 4.5);
6. Waste Management Plan (Section 4.6); and
7. Rail Management Plan (Section 0).

## 2.3 STRUCTURE

This EMP includes four key parts:

Part 1 – Introduction. This part contains an overview of the West Angelas Operations.

Part 2 – Framework. This part details the framework within which the EMP operates.

Part 3 – Implementation. This part details the processes under which the EMP is implemented.

Part 4 – Environmental Management Plans.

The environmental management plan for each environmental factor has been developed in response to the impacts identified during the environmental impact assessment process. The management plans contain the relevant environmental background, objectives, management and monitoring actions for each factor.

Each management plan is structured in a consistent format as outlined in Table 1.

**Table 1 Management plan framework**

| **Management Plan** | | |
|---|---|---|
| Description | | Provides a brief description of the environmental factor. |
| Environmental factors to be managed | | Outlines the anticipated operational issues associated with the Proposal. |
| Performance management | Environmental objectives | Establishes over-arching objectives for environmental management of the West Angelas Operations. |
| | Targets | Establishes specific targets for environmental management of the West Angelas Operations based on over-arching management objectives. |
| | Performance indicators | Provides details on the key indicators that will be used to determine the Proponent's achievement of the targets. |
| Implementation | Management actions | Provides details of actions to manage environmental risks to prevent, minimise and mitigate potential environmental impacts. |
| Monitoring | | Provides information on monitoring activities to be performed. |
| Contingencies | | Provides details of actions to be taken in the event that specified criteria are met or exceeded. |

Some management actions are cross referenced between individual environmental management plans as they may be relevant to the management of more than one environmental aspect.

# 3 IMPLEMENTATION

## 3.1 RESPONSIBILITIES

Implementation of the EMP is the responsibility of all site personnel working for, or on behalf of, Rio Tinto. Key personnel accountable for the implementation and review of this EMP are:

- West Angelas General Manager – accountable for overall environmental performance at West Angelas Operations.
- Superintendent Environment – accountable for implementing the EMP and achieving environmental objectives.
- Site Environmental Advisor – responsible for day to day verification that the environmental performance at West Angelas Operations complies with the intent of the EMP.
- Environmental Monitoring Officer – responsible for day to day environmental monitoring and recording.
- Hydrogeology Technical Officer – responsible for day to day hydrogeological monitoring and recording.

## 3.2 ENVIRONMENTAL AWARENESS AND INDUCTIONS

All personnel on site are required to complete an environmental induction to ensure they are aware of their responsibilities.

The environmental induction will provide employees with an understanding of the key environmental risks on site and the environmental incident reporting process.

## 3.3 INCIDENTS AND CORRECTIVE ACTIONS

All environmental incidents will be recorded in the incident database in accordance with the Rio Tinto Iron Ore (WA) Non-conformance, incidents and action management work practice. Environmental incidents are classified using the Rio Tinto Iron Ore Environmental Incident Classification Guide. Incidents will be investigated and appropriate measures implemented to prevent recurrence. Where applicable, environmental incidents will be reported to the relevant government agency.

The Site Environmental Advisor is responsible for conducting regular reviews of all incidents reported within their site/division/project and/or areas of responsibility to ensure any trends are identified and to assess the effectiveness of preventative measures.

## 3.4 EMERGENCY RESPONSE

The West Angelas Local Emergency Management Plan outlines procedures to minimise impacts from emergency situations.

Basic emergency response training will be provided to key personnel. An emergency response team will complete regular training and assessment in emergency scenarios. Appropriate emergency response equipment will be available on-site.

## 3.5 AUDITING AND REPORTING OF ENVIRONMENTAL COMPLIANCE

Compliance auditing and reporting will be undertaken in accordance with the West Angelas Compliance Assessment Plan.

At a minimum, the following environmental reporting will be conducted:

**Table 2 Environmental reporting commitments**

| Report | Reporting frequency | Relevant Agency | Relevant Legislation |
|---|---|---|---|
| Annual Environmental Report (AER) | Annually | DER | DER Licence |
| Annual Environment Report (AER) | Annually | DMP | *Mining Act 1978* |
| Annual Audit Compliance Report (AACR) | Annually | DER | DER Licence |
| Ministerial Statement Compliance Report | Annually | OEPA | Ministerial Statement 970 |
| Triennial Environmental Report (TER) | Triennially | DSD | *Iron Ore (Robe River) Agreement Act 1964* |
| Native Vegetation Clearing Permit Annual Report. | Annually | DMP | NVCP |
| National Pollutant Inventory (NPI) Emissions Report. | Annually | DoE | NPI NEPM |
| Annual Aquifer Review (AAR). | Annually | DoW | *Rights in Water Irrigation Act 1914* |
| Triennial Aquifer Review (TAR). | Triennially | DoW | *Rights in Water Irrigation Act 1914* |
| National Greenhouse and Energy Reporting System (NGERS). | Annually | DCCEE | NGER Act 2007 |

## 3.6 DOCUMENT REVIEW

This EMP is intended to be a dynamic document that will be reviewed and updated as required throughout the duration of the West Angelas operations.

Significant changes to the EMP will be developed in consultation with relevant government agencies.

# 4 ENVIRONMENTAL MANAGEMENT PLANS

It is intended that the West Angelas Operations will be managed under one Environmental Management Program, comprising individual environmental management plans. Each management plan can be used on a stand-alone basis for implementation.

This Program has been developed in compliance with Condition 5 of Ministerial Statement 970.

## 4.1 GROUNDWATER MANAGEMENT PLAN

### 4.1.1 Description

- Two regional aquifer systems have been identified at West Angelas. The first is in the Jeerinah Formation in the core of the Wonna Munna anticline which is comprised of mudstones, shales and ultramafic intrusive dolerite sills. The permeability and groundwater storage is generally low in this formation, except where there are local fracture systems associated with several north-west south-east trending regional lineaments. Groundwater within the Jeerinah Formation declines steeply in a north-south direction from the central Jeerinah Plateau, where groundwater levels are relatively shallow, ranging between 10-20m below ground level, into alluvial valley systems which flank this plateau to the north and south where groundwater levels are very deep, up to 140m below ground level. The very steep water level gradients is indicative of very low permeabilities or a lack of hydraulic connection altogether between the Jeerinah plateau and the flanking valleys. However, the hydraulic isolation between the formations may also be affected by faulting.
- The Marra Mamba Iron Formation which surrounds the Jeerinah Formation hosts the majority of the mineralisation in a series of discontinuous deposits located on the north and south limbs of the regional anticline and the second aquifer system. Aquifers associated with mineralisation are very deep, porous and therefore, permeable. These aquifers have a very low hydraulic gradient from east to west, and are considered to be confined "bathtub" type aquifers, hydraulically isolated by the low permeability of the surrounding rock as a result of structural folding.
- Dewatering is required to facilitate access to below watertable ore. Water from the mine dewatering bores is used on-site to supply water for operational purposes (processing and dust control) wherever practicable. Any surplus water, exceeding operational water demand is discharged to the environment.
- The mining operations are supplied with water from the mine dewatering bores and water from the Turee Creek B Borefield, located approximately 30 kilometres west of the mine site (Figure 3).

*Stygofauna*

- Stygofauna tend to be highly specialised to, and obligate dwellers of, subterranean groundwater habitats. Stygofauna are known to be present in a variety of rock types including karst (limestones), fissured rock (e.g. granite) and porous rock (e.g. alluvium).
- Both dewatering of the orebody aquifers and water abstraction from the Turee Creek "B" Borefield aquifer has the potential to reduce the available habitat for stygobitic fauna.

- Subterranean fauna surveys have been undertaken over the entire West Angelas area since 1979. Baseline stygofauna surveys were conducted during 1998, prior to the commencement of dewatering. Monitoring surveys were undertaken during 2002, 2003, 2004, 2008 and 2012. Sampling of orebody aquifers has yielded no stygofauna specimens to date.
- Aquifers associated with the orebodies are generally deep, confined aquifers, hydraulically isolated by low permeability surrounding rock and are not expected to support stygal communities.
- Stygofauna have been recorded in other parts of the region, however, these records are generally associated with the saturated superficial alluvial aquifers, such as at the Turee Creek "B" Borefield.
- The risk of dewatering reducing available habitat for stygofauna is considered low due to the apparent lack of prospective habitat within the orebody aquifers. Furthermore, no stygofauna have been recorded during surveys of areas that are being, or will be, dewatered. Adjacent Jeerinah Formation aquifer systems in prospective habitats that support recorded stygofauna are not expected to be affected by drawdown due to the lack of hydraulic connection with the orebody aquifer.

It is difficult to effectively demonstrate that a significant decline in stygofauna abundance or diversity has occurred based on sampling data. Capture success is highly variable. Stygal communities also experience natural fluctuations and sampling data reflects this variability over time. A habitat monitoring program will replace the traditional stygofauna sampling approach.

### 4.1.2 Environmental aspects to be managed

The potential impacts of the operations on groundwater values and the causal aspects of the operations requiring management are as follows:

- **Groundwater drawdown** due to mine dewatering;
- **Reduction in groundwater quality** due to potential contamination;
- **Loss of stygofauna habitat** as a result of changes in groundwater availability;
- **Deterioration of stygofauna habitat** as a result of changes in groundwater quality, including potential contamination; and
- **Decline of phreatophytic vegetation condition** (outside natural variability) as a result of changes in groundwater availability.

Dewatering will be undertaken in accordance with the licence to abstract water, issued by the Department of Water (**DoW**) under the *Rights in Water and Irrigation Act 1914*.

### 4.1.3 Performance management

Environmental targets and performance indicators have been developed based on groundwater management objectives at West Angelas (Table 3).

**Table 3 Groundwater management objectives, targets and performance indicators**

| Management objective | Target | Performance indicators |
|---|---|---|
| To ensure sustainable use and protection of existing groundwater resources. | Water supply will be sourced from dewatering bores wherever practicable in preference to sourcing new water. | Development and documentation of the site water balance.<br>Reconciliation of results from monitored groundwater abstraction against the site water balance. |
| | No unacceptable changes in the regional aquifer levels. | Monitoring data shows no unacceptable changes in the regional aquifer levels. |
| To manage groundwater abstraction in compliance with all licence requirements. | Groundwater abstraction to occur only from licenced sources in compliance with licence conditions and limits. | Reconciliation of results of monitored groundwater abstraction volumes against licence conditions and limits. |
| To maintain the existing quality of groundwater resources. | No contamination of groundwater. | Monitoring data shows no unacceptable changes in groundwater quality.<br>*Also see Waste Management Plan.* |
| | Compliance with relevant guidelines for groundwater quality (taking into consideration natural background water quality). | Monitoring data shows no unacceptable changes in groundwater quality. |
| To preserve the environmental values of the dependent ecology. | No significant decline in subterranean habitat parameters (outside natural variability) as a result of groundwater drawdown. | Assessment of time series change in subterranean habitat parameters (water levels and water quality). |
| | No significant decline in phreatophytic vegetation condition (outside natural variability) as a result of groundwater drawdown. | Assessment of time series change in phreatophytic vegetation monitoring data.<br>*Also see Vegetation and Flora Management Plan.* |

### 4.1.4 Implementation

Specific actions have been identified to assist in achieving groundwater management objectives (Table 4).

**Table 4 Groundwater management actions**

| Parameter | Action |
|---|---|
| Water abstraction | Water supply will be sourced from dewatering bores wherever practicable. |
| | Groundwater will only be drawn from points licenced by the DoW. |
| | Copies of all water licences, permits and operating strategies will be available via the Rio Tinto Iron Ore Health, Safety, Environment and Quality Management System (HSEQMS). |
| | The volume of groundwater abstracted will be recorded, reconciled regularly against the licence limit and will not exceed the licence limit. |
| Water use | A 'site water balance' will be developed and maintained to facilitate site's understanding of current and future water demands and potential effects on upstream and downstream users. |
| | Water from the mine dewatering bores will be used on-site wherever practicable. |
| Water quality | A water quality monitoring program will be established for groundwater. |
| | Equipment used to monitor groundwater quality will be calibrated and associated records maintained or alternatively, a NATA accredited laboratory will be engaged to conducted water quality analysis. |
| | Pits will be backfilled to above the natural ground water level as far as practicable to minimise the deterioration of groundwater quality. |
| Induction | Prior to engagement on site, all staff will be inducted on:<br>• water conservation,<br>• potential for spills to contaminate groundwater,<br>• consequences of groundwater contamination,<br>• proper storage and handling of hydrocarbons/chemicals,<br>• spill response procedures, and<br>• issues relevant to the protection of stygofauna, where it is related to their roles & responsibilities. |
| Stygofauna | Water supply will be sourced from dewatering bores wherever practicable to reduce potential for drawdown in the Jeerinah Formation. |
| | Where stygofauna are known to be present in an aquifer, that aquifer will be monitored for subterranean habitat parameters (water levels and water quality). |

| Parameter | Action |
|---|---|
| | In the event that new bores are to be installed within an aquifer that has not yet been monitored for stygofauna, a stygofauna assemblage baseline survey should be undertaken. If sampling indicates that stygofauna species of significant conservation value are present, bores will be added to the monitoring schedule for subterranean habitat parameters. |
| Phreatophytic vegetation | Monitoring to assess the impacts of drawdown on phreatophytic vegetation (*Eucalyptus* sp.) will be undertaken.<br>*See Vegetation and Flora Management Plan*. |

### 4.1.5 Monitoring program

The monitoring program for groundwater at WAO (Table 5) is designed to ensure that operations are consistent with the prescribed management actions. Monitoring will measure the success of these actions in accordance with the management objectives and targets.

**Table 5 Groundwater monitoring program**

| Topic | Frequency | Parameters | Procedure | Purpose |
|---|---|---|---|---|
| Groundwater levels | Monthly | Abstraction volume | As per the Groundwater Abstraction Licence and Groundwater Operating Strategy | To track instantaneous and cumulative groundwater abstraction volumes and ensure compliance with licence conditions. |
| | | Water level elevation | As per the Groundwater Operating Strategy | To track changes in groundwater levels and ensure no unacceptable changes in the regional aquifer levels as a result of groundwater abstraction. |
| Groundwater quality | Monthly | EC, pH, and temperature | Water quality sampling and analysis as per the Part V operating licence and Groundwater Operating Strategy | To ensure no unacceptable changes in groundwater quality. |
| | Quarterly | TPH, Na, K, Ca, Mg, Cl, $CO_3$, $HCO_3$, $SO_4$, $NO_3$, Metals, TSS, Total-N and Total P | | |
| | Annually | Potability analysis | As per the Groundwater Operating Strategy | To determine water quality prior to on-site use or excess water discharge. |
| Stygofauna | Annually | Subterranean habitat parameters (groundwater levels and groundwater quality) | As per monitoring parameters for groundwater levels and groundwater quality | Assessment of time series change in subterranean habitat quantity and quality. |
| | Opportunistically | Stygofauna abundance | EPA Guidance Statement No. 54 - *Consideration of Subterranean Fauna in Groundwater and Caves during Environmental Impact Assessment in Western Australia* (2003),<br>Technical Appendix to Guidance Statement no. 54: *Sampling Methods and Survey Considerations for Subterranean Fauna in Western Australia* (2007) | Assessment of subterranean fauna species and abundance. |
| *Surface water will be monitored and managed as specified in the Surface Water Management Plan.* | | | | |
| *Phreatophytic vegetation in the Turee Creek "B" Borefield to be monitored as specified in the Vegetation and Flora Management Plan.* | | | | |
| *Potential groundwater contamination will be monitored and managed as specified in the Waste Management Plan.* | | | | |

Groundwater quality and quantity data collected throughout the monitoring program will be included in the Annual Aquifer Review

### 4.1.6 Contingencies

Contingency actions have been developed to be enacted if monitoring indicates that the environmental objectives and targets for groundwater management are not being achieved (Table 6).

**Table 6 Groundwater management contingency actions**

| Management objective | Trigger | Action |
|---|---|---|
| To ensure sustainable use and protection of existing water resources. | Groundwater levels recorded in regional aquifers below predicted natural range for successive monitoring events | 1. Investigate potential causes of groundwater level variance including:<br>i. review data quality to identify any errors in data, collection or interpretation, anomalous readings etc.,<br>ii. review seasonal rainfall data and regional groundwater water levels,<br>iii. review groundwater abstraction volumes / rates and extent of drawdown.<br>2. If groundwater abstraction is identified as cause and a recovering trend is not evident following the next monitoring;<br>i. notify relevant stakeholders,<br>ii. identify remedial options (e.g. reassess groundwater abstraction volumes / rates, cease pumping and / or utilise alternative bores) on advice on relevant stakeholders,<br>iii. implement remedial actions as required. |
| To manage groundwater abstraction in compliance with all licence requirements. | Groundwater abstraction volumes exceed licence limits | 1. Immediately decrease or cease groundwater abstraction.<br>2. Report as Environmental Incident.<br>3. Notify relevant stakeholders. |
| To maintain the existing quality of groundwater resources. | Groundwater quality indicates a substantial deviation from baseline quality for successive monitoring events | 1. Investigate extent and potential causes of water quality variance including:<br>i. review data quality to identify any errors in data, collection or interpretation, anomalous readings etc.,<br>ii. review potential sources of contamination and pathways,<br>2. Remove identified source/s of contamination.<br>3. If a recovering trend is not evident following the next monitoring event;<br>i. notify relevant stakeholders,<br>ii. identify remedial options to maintain sufficient groundwater habitat,<br>iii. implement remedial actions as required. |

| Management objective | Trigger | Action |
|---|---|---|
| | Groundwater quality adversely affected by a spill | 1. Mitigate (initiate spill response procedures) including:<br>i. control the spill,<br>ii. contain the spill,<br>iii. clean up the spill, and<br>iv. report the spill as an Environmental Incident.<br>2. Investigate cause.<br>3. Implement remedial actions, as required.<br>4. Review environmental incidents relating to spills.<br>5. Review relevant environmental procedures (e.g. spill response procedures).<br>6. Review the need for personnel training (e.g. in spill response procedures). |
| To preserve the environmental values of the dependent ecology. | Subterranean habitat parameters (water levels and water quality) indicates a substantial change relative to baseline for successive monitoring events | 1. Investigate potential causes of change to subterranean habitat parameters.<br>2. If a recovering trend is not evident following the next monitoring event;<br>i. identify remedial options to maintain sufficient groundwater habitat,<br>ii. remove potential source/s of contamination from the most likely pathway.<br>3. Implement remedial actions, as required. |
| | Significant[1] decline of phreatophytic vegetation condition relative to baseline for successive monitoring events | 1. Investigate potential causes of decline including;<br>i. review data quality to identify any errors in data, collection or interpretation, anomalous readings etc.,<br>ii. review site and tree condition information to determine the presence of factors likely to cause decline in tree health – e.g. fire or flood damage, evidence of insect activity or pathogens etc.,<br>iii. review seasonal rainfall data and regional groundwater water levels,<br>iv. review groundwater abstraction volumes / rates and extent of drawdown,<br>v. review tree health monitoring results from regional reference sites.<br>2. Increase frequency of monitoring as appropriate.<br>3. If groundwater abstraction is identified as cause and a recovering trend is not evident following the next monitoring;<br>i. notify relevant stakeholders,<br>ii. identify remedial options (e.g. reassess groundwater abstraction volumes / rates, cease pumping, surface irrigation, supplementation and / or rehabilitation),<br>iii. implement remedial actions as required. |

## 4.2 SURFACE WATER MANAGEMENT PLAN

### 4.2.1 Description

- Deposits A, A west, B, E and the majority of Deposit F (pits F1 and F2) are located within the upper reaches of the Turee Creek East catchment which forms part of the regional Ashburton River Catchment (Figure 4). The upper catchment has a complex drainage pattern characterised by intermittent flow and infrequent wide-spread flooding, depending on the occurrence of high intensity rainfall events. Turee Creek East represents the most significant named watercourse in the area with a catchment area of approximately 2,050 km².
- The F3 orebody, part of Deposit F, is located in the upper reaches of the Weeli Wolli Creek catchment, part of the regional Upper Fortescue River catchment, immediately west of the regional Ashburton River catchment. The Weeli Wolli Creek catchment covers an area of approximately 3,991 km². Weeli Wolli Creek flows in a north easterly direction and merges with Marillana Creek 60 km downstream from Deposit F.
- The surface hydrology is dominated by small first-order streams and typically small sub-catchments. The hills are characterised by steep incised drainage channels. However as the channels extend out from the hillside to the very flat valley floor, they transform into shallow, poorly defined drainage lines typical of overland flow depending on the occurrence of high rainfall events. The location and extent of these shallow drainage lines on the valley floor are often hard to define.
- Ephemeral unnamed tributaries of the Turee Creek East traverse West Angelas. The northernmost of these tributaries naturally flowed across Deposit B. The southernmost of these tributaries naturally flowed along the valley floor, crossing Deposit F and Deposit E and then meandered north westerly across Deposit A. Surface water flows that are intercepted by operations have, and will continue to be diverted to maintain natural flows as far as practicable. Where it is not possible to continue flow within its natural catchment, surface water flows will be diverted to facilitate continued flow in the adjacent catchment.
- Water from the mine dewatering bores is used on-site to supply water for operational purposes (processing and dust control) wherever practicable. Any surplus water, exceeding operational water demand is discharged to the environment.

### 4.2.2 Environmental aspects to be managed

The potential impacts of the operations on surface water values and the causal aspects of the operations requiring management are as follows:

- **Alteration of natural surface water drainage patterns** as a result of development.
- **Decline of Mulga community health** (outside natural variability) as a result of alteration of existing surface water drainage patterns (drainage shadow).

- **Reduction in surface water quality** as a result of increased erosion and potential contamination (sediments and hydrocarbons/chemicals) from drainage management systems and surface water discharge.
- **Decline or artificial proliferation of riparian vegetation community structure,** species diversity, cover or abundance (outside natural variability) as a result of surface water discharge.

Excess water will be discharged to the environment in accordance with an environmental licence, issued by the Department of Environment Regulation (**DER**) under Part V of the *Environmental Protection Act 1986*.

### 4.2.3 Performance management

Environmental targets and performance indicators have been developed based on surface water management objectives at West Angelas (Table 7).

**Table 7 Surface water management objectives, targets and performance indicators**

| Management objective | Target | Performance indicators |
|---|---|---|
| To maintain the existing local hydrological regime. | No significant change in natural surface water drainage patterns (outside natural variability). | Visual inspections show no unacceptable changes in natural drainage patterns, surface water flows are maintained. |
| | Only water exceeding on-site requirements will be discharged to natural drainage lines. | Development and documentation of the site water balance.<br>Reconciliation of monitored surface water discharge volumes against the site water balance. |
| To maintain the existing quality of surface water resources. | No contamination of surface water. | Monitoring data shows water quality meets the criteria set out in licences and relevant guidelines.<br>*Also see Waste Management Plan.* |
| | Compliance with licence conditions and relevant guidelines for discharge water quality, no significant deterioration of downstream surface water quality (outside natural variability). | Monitoring data shows no unacceptable changes in surface water quality, water quality meets the criteria set out in licences and relevant guidelines. |
| To manage surface water discharges in compliance with all licence requirements. | Surface water discharge to occur only from licenced sources in accordance with licence conditions and limits. | Reconciliation of monitored surface water discharge volumes against licence conditions and limits. |
| To preserve the environmental values of the dependent ecology. | No significant decline in Mulga community health (outside natural variability) as a result of drainage shadow. | Reconciliation of Mulga monitoring data against baseline data.<br>*Also see Vegetation and Flora Management Plan.* |
| | No significant decline or artificial proliferation of riparian vegetation community structure, species diversity, cover or abundance (outside natural variability) as a result of surface water discharge. | Reconciliation of riparian vegetation monitoring data against baseline data.<br>*Also see Vegetation and Flora Management Plan.* |

### 4.2.4 Implementation strategy

Specific actions have been identified to assist in achieving surface water management objectives (Table 8).

**Table 8 Surface water management actions**

| Parameter | Action |
|---|---|
| Planning | Emergency response procedures will be developed for the following:<br>• failures of large water diversion and retention structures;<br>• unplanned discharges; and<br>• significant hydrocarbon and/or chemical spills. |
| | The profile of waste dumps (e.g. height and slope angles) will be designed to ensure that they are not prone to significant erosion / sedimentation from surface water run-off. |
| | Mineral waste dumps located near drainage features will be monitored to assess for scouring and erosion. Rock armouring, or other stabilising material, will be utilised if necessary. |
| Water use | A 'site water balance' will be developed and maintained to facilitate site's understanding of current and future water demands and potential effects on upstream and downstream users. |
| | Water will be used on-site wherever practicable. |
| | Only surplus water, exceeding operational water demand will be discharged to the environment. |
| Water quality | A water quality monitoring program will be established to analyse TPH in surface water.<br>*See Waste Management Plan.* |
| Drainage management | Culverts will be used where appropriate to minimise impacts on natural surface water drainage patterns. |
| | Surface water flows that are intercepted by operations will be diverted to maintain natural flows downstream as far as practicable. |
| | Surface water collected on-site will be managed via on-site drainage management systems. |
| | Surface water collected on-site will be contained in sediment traps to reduce sediment loads prior to re-use or discharge. |
| | Surface water collected on-site that potentially contains hydrocarbons will be directed to oily water separation facilities. |
| | On-site drainage management systems will be routinely inspected and maintained to ensure they remain effective. |
| Mulga | Additional culverts will be incorporated along the rail and access road as appropriate to minimise impacts of drainage shadow on Mulga communities adjacent to the rail line. |
| | Culverts will be routinely inspected and maintained to ensure they remain effective. |

| Parameter | Action |
|---|---|
| | Monitoring will be undertaken to assess the impacts of drainage shadow on Mulga communities adjacent to the rail line.<br>*See Vegetation and Flora Management Plan.* |
| Discharge | Abstracted water will only be discharged from licenced discharge points. |
| | The volume of water discharged will be recorded, reconciled regularly against the licence limit and will not exceed the licenced limit. |
| | Copies of water licences, permits and operating strategies will be available via the Rio Tinto HSEQMS |
| | Erosion protection will be utilised to minimise potential erosion and scouring at the discharge point. |
| | Sampling will be undertaken to ensure water quality meets the criteria specified in licences and relevant guidelines (taking into consideration natural background water quality). |
| Riparian Vegetation | Monitoring will be undertaken to assess the impacts of discharge on riparian vegetation.<br>*See Vegetation and Flora Management Plan.* |
| | Management of weeds will be undertaken.<br>*See Vegetation and Flora Management Plan.* |
| Induction | Prior to engagement on site, all staff will be inducted on:<br>• drainage management procedures,<br>• potential for spills to contaminate surface water,<br>• consequences of surface water contamination,<br>• proper storage and handling of hydrocarbons/chemicals,<br>• spill response procedures. |

### 4.2.5 Monitoring program

The monitoring program for surface water (Table 9) is designed to ensure that operations are consistent with the prescribed management actions. Monitoring will measure the success of these actions in accordance with the management objectives and targets.

**Table 9 Surface water monitoring program**

| Topic | Frequency | Parameters | Procedure | Purpose |
|---|---|---|---|---|
| Surface water quality | Quarterly | TPH in surface water | Water quality sampling and analysis as per the Part V operating licence | To ensure surface water quality is not compromised. |
| Drainage management system | Opportunistically | Surface water flows are maintained | Visual inspection | To monitor the effectiveness of the on-site drainage management systems. |
| | Opportunistically | Integrity of drainage management systems | Visual inspection | To monitor the integrity of the on-site drainage management systems |
| Discharge volume | Monthly | Discharge volume | Water quantity sampling as per the Part V operating licence | To track instantaneous and cumulative discharge volumes and ensure compliance with licence conditions. |
| | Quarterly | Extent of saturation | Visual inspection as per the Part V operating licence | To track extent of saturation and ensure compliance with licence conditions. |
| Discharge water quality | Monthly | EC, pH and temperature | Water quality sampling and analysis as per the Part V operating licence | To ensure compliance with licence conditions and ensure no unacceptable change in downstream surface water quality as a result of discharge. |
| | Quarterly | TPH, Na, K, Ca, Mg, Cl, $CO_3$, $HCO_3$, $SO_4$, $NO_3$, Metals and TSS | | |
| Discharge outlet | Opportunistically | Integrity of erosion control structures and evidence of erosion | Visual inspection (as per the Part V operating licence) | To monitor the integrity of erosion control structures. |
| *Riparian vegetation along drainage lines receiving discharge to be monitored as specified in the Vegetation and Flora Management Plan.* | | | | |
| *Mulga adjacent to the rail to be monitored as specified in the Vegetation and Flora Management Plan.* | | | | |
| *Weeds will be monitored and managed as specified in the Vegetation and Flora Management Plan.* | | | | |
| *Potential surface water contamination will be managed as specified in the Waste Management Plan.* | | | | |

### 4.2.6 Contingencies

Contingency actions have been developed to be enacted if monitoring indicates that the environmental objectives and targets for surface water management are not being achieved (Table 10).

**Table 10 Surface water management contingency actions**

| Management objective | Trigger | Action |
|---|---|---|
| To maintain the existing local hydrological regime | Surface water flows not maintained | 1. Investigate cause.<br>2. Implement remedial actions (e.g. reinstate surface water flows, divert flows) as required. |
| | Integrity of on-site drainage management system compromised | 1. Investigate cause.<br>2. Undertake maintenance of on-site drainage management system as required.<br>3. Implement remedial actions as required. |
| To maintain the existing quality of surface water resources. | Water quality outside criteria set in licence conditions or relevant guidelines (taking into consideration natural background water quality) for successive monitoring events | 1. Immediately decrease or cease affected discharge.<br>2. Investigate potential causes of water quality variance including:<br>i. review data quality to identify any errors in data, collection or interpretation, anomalous readings etc.,<br>ii. review potential sources of contamination,<br>3. If discharge is identified as cause and a recovering trend is not evident following the next monitoring;<br>i. notify relevant stakeholders,<br>ii. identify alternative water management options (e.g. increase on-site use),<br>iii. identify remedial options on advice on relevant stakeholders.<br>iv. implement remedial actions as required. |

| Management objective | Trigger | Action |
|---|---|---|
| | Surface water quality adversely affected by a spill | 1. Mitigate (initiate spill response procedures) including:<br>i. control the spill,<br>ii. contain the spill,<br>iii. clean up the spill, and<br>iv. report the spill as an Environmental Incident.<br>2. Investigate cause.<br>3. Implement remedial actions as required.<br>4. Review environmental incidents relating to spills.<br>5. Review relevant environmental procedures (e.g. spill response procedures).<br>6. Review the need for personnel training (e.g. in spill response procedures). |
| | Visible erosion or associated downstream water quality impacts occur | 1. Investigate potential causes of erosion.<br>2. Undertake maintenance of discharge outlet as required.<br>3. Implement remedial actions (e.g. reassess discharge volumes / rates, increase channel stability or vegetation cover) as required. |
| To manage surface water discharges in compliance with all licence requirements. | Discharge volumes or extent of saturation exceed licence limits | 1. Immediately decrease or cease discharge (except emergency discharge)<br>2. Report as Environmental Incident<br>3. Notify relevant stakeholders |
| To preserve the environmental values of the dependent ecology. | Significant[2] decline in Mulga community health (outside natural variability) for successive monitoring events | 1. Investigate potential causes of degradation of vegetation condition including;<br>i. review data quality to identify any errors in data, collection or interpretation, anomalous readings etc.,<br>ii. review site and tree condition information to determine the presence of factors likely to cause degradation – e.g. fire, storm damage etc.,<br>iii. review seasonal rainfall data.<br>2. If drainage management is identified as cause and a recovering trend is not evident following the next monitoring event;<br>i. notify relevant stakeholders,<br>ii. identify remedial options (e.g. reassess drainage management systems, surface irrigation, supplementation and / or rehabilitation) on advice from relevant stakeholders,<br>iii. implement remedial actions as required. |

| Management objective | Trigger | Action |
|---|---|---|
| | Significant[3] decline or artificial proliferation of riparian vegetation community structure, species diversity, cover or abundance (outside natural variability) for successive monitoring events | 1. Investigate potential causes of decline or artificial proliferation of vegetation or degradation of vegetation condition including;<br>i. review data quality to identify any errors in data, collection or interpretation, anomalous readings etc.,<br>ii. review site and vegetation condition information to determine the presence of factors likely to cause foliage loss – e.g. fire, storm damage, insect activity, waterlogging, foliage pathogens etc.,<br>iii. review seasonal rainfall data,<br>iv. review surface water discharge volumes / rates and extent of discharge,<br>v. review vegetation monitoring results from regional reference sites.<br>2. If surface water discharge is identified as cause and a recovering trend is not evident following the next monitoring event;<br>i. notify relevant stakeholders,<br>ii. identify remedial options (e.g. reassess groundwater abstraction volumes / rates, reassess surface water discharge volumes / rates, surface irrigation, supplementation and / or rehabilitation) on advice from relevant stakeholders,<br>iii. implement remedial actions as required. |

## 4.3 VEGETATION AND FLORA MANAGEMENT PLAN

### 4.3.1 Description

- West Angelas is situated within the Hamersley subregion of the Pilbara (**PIL**) Bioregion as defined in the Interim Biogeographic Regionalisation of Australia (**IBRA**) Report.
- West Angelas lies entirely within the Pilbara region of the Eremaean Botanical Province as defined by Beard (1975). The vegetation of this province is typical of arid landscapes. According to Beard the predominant vegetation associations in the survey area are:
    - Low woodland; continuous Mulga *Acacia aneura* woodland communities over spinifex *Triodia basedowii* and *Triodia epactia* hummock grasslands on stony undulating plains; and
    - Low scattered tree steppe; Snappy Gum *Eucalyptus leucophloia* over spinifex *Triodia wiseana* hummock grassland on stony undulating plains.
- The Priority 1 West Angelas Cracking Clay Priority Ecological Community (**PEC**) occurs extensively within the region. The location and extent of recorded PEC's is shown on Figure 5. This community is defined as 'open tussock grasslands of *Astrebla pectinata, A. elymoides, Aristida latifolia* in combination with *Astrebla squarrosa* and low scattered shrubs of *Sida fibulifera*, on basalt derived cracking-clay loam depressions and flowlines'. The West Angelas Cracking Clays are significant because they are relatively uncommon in the region and because they are in very good condition, attributed to the absence of historic cattle grazing. Threats to this community include: clearing for mining expansion and future infrastructure development; weed invasion; and changes in fire regimes.
- Numerous additional ecosystems are deemed to be "ecosystems at risk" (Kendrick 2003) and are therefore considered locally significant. Of these, the following ecosystems are relevant to the West Angelas area:
    - Grove/intergrove mulga communities: The grove/intergrove mulga in the region is in very good condition however, this vegetation is considered to be under threat from grazing and trampling, weed ingress (particularly by Ruby Dock **Acetosa vesicaria*), and changes to hydrological regimes. Grove/intergrove Mulga communities are widely recognised as being dependent on patterns of surface water flow. The diversion of sheet flow or concentration of sheet flow to particular areas is likely to cause shadowing impacts on these mulga communities.
    - Valley floor mulga: "Valley floor mulga" is a very broad description of mulga communities (previously Acacia aneura but now including a number of species). Valley floor mulga is also recognised as being dependent on patterns of surface water flow and is considered to be under threat from the same factors listed above.

- One species of Declared Rare Flora (DRF) is known from the West Angelas area. Hamersley Lepidium, *Lepidium catapycnon* was recorded next to a creek and on slopes adjacent to the southern base of West Angelas Hill. The total population was in excess of one hundred individuals in several patches within a few hundred metres of each other, with the population extending upslope to below the low cliffs on the upper hill slope.
- Priority Flora species have been recorded during surveys at West Angelas. The location of Priority Flora is shown on Figure 6.
- West Angelas is not located within a pastoral lease and, as a result, is not actively grazed. Subsequently, the vegetation condition is generally assessed to be in very good to excellent condition. The disturbance most commonly observed was the presence of weed species. *Acetosa vesicaria*, commonly known as Ruby Dock is classified as a High Priority weed by DPaW. It is associated with disturbed areas at West Angelas and the extent of its infestation is currently considered to be low.
- The WAO will result in the clearing of native vegetation for development of mine pits, waste dumps, processing facilities, stockpiles, accommodation, roads, railway and other associated infrastructure.
- Alteration of the existing hydrological regime may also result in decline or artificial proliferation of vegetation or degradation of vegetation condition.

### 4.3.2 Environmental aspects to be managed

The potential impacts of the operations on vegetation and flora values and the causal aspects of the operations requiring management are as follows:

- **Clearing of vegetation** for development of mine pits, waste dumps, processing facilities, stockpiles, accommodation, roads, railway and other associated infrastructure.
- **Decline or artificial proliferation of vegetation condition** (outside natural variability) as a result of:
  - alteration of the existing hydrological regime by:
    - groundwater abstraction,
    - discharge of excess water to natural drainage lines.
  - introduction or spread of weeds by:
    - vehicle or human movement,
    - increased water availability from excess water discharge.

- dust generated by:
  - vehicle movement,
  - mining and processing,
  - wind erosion.
- increased potential risk of fire outbreak by:
  - storage and use of flammable materials,
  - provision of ignition sources (e.g. welding, grinding),
  - blasting or incorrect storage or handling of explosives required for blasting.

  Changes to the local fire regime, such as a change in the frequency and intensity of fires, may alter vegetation communities.

### 4.3.3 Performance management

Environmental targets and performance indicators have been developed based on vegetation and flora management objectives at West Angelas (Table 11).

**Table 11 Vegetation and flora management objectives, targets and performance indicators**

| Management objective | Target | Performance indicators |
|---|---|---|
| To minimise clearing of vegetation. | Opportunities to minimise clearing of vegetation are investigated. | Reconciliation of actual clearing against approval boundaries. |
| | Where clearing of vegetation is unavoidable, progressive rehabilitation will be undertaken, where possible. | Progressive rehabilitation of cleared areas is being undertaken, where possible. |
| To manage clearing of vegetation in compliance with all approval requirements. | Clearing of vegetation to occur only from within approval boundaries and in compliance with approval conditions. | Reconciliation of actual clearing against approval boundaries. |
| | Cumulative clearing totals (in hectares) within approval limits and in compliance with approval conditions. | Reconciliation of clearing (in hectares) against approval limits. |
| To protect conservation significant vegetation communities and species. | Avoid conservation significant vegetation communities and species. | Reconciliation of actual clearing against approval boundaries. |
| | No significant decline in phreatophytic vegetation condition (outside natural variability) as a result of groundwater drawdown. | Reconciliation of phreatophytic vegetation monitoring data against baseline data.<br>*Also see Groundwater Management Plan.* |
| | No significant decline in Mulga community health as a result of drainage shadow. | Reconciliation of Mulga monitoring data against baseline data.<br>*Also see Surface Water Management Plan.* |
| | No significant decline or artificial proliferation of riparian vegetation community structure, species diversity, cover or abundance (outside natural variability) as a result of surface water discharge. | Reconciliation of riparian vegetation monitoring data against baseline data.<br>*Also see Surface Water Management Plan.* |
| To prevent the displacement of native species by weed species. | No substantial increase in the type or abundance of weeds in the area (with a particular focus on *Acetosa vesicaria*, Ruby Dock). | Reconciliation of identified weed species / abundance against baseline data. |
| To ensure that dust emissions do not adversely affect environmental values. | No adverse impacts on vegetation as a result of dust generated by WAO. | Ambient dust monitoring data and visual dust assessments show no unacceptable dust levels.<br>*Also see Dust Management Plan.* |
| To ensure that fire does not adversely affect environmental values. | No vegetation impacted by fire as a result of activities related to WAO. | Records show no fire-related damage to vegetation. |

### 4.3.4 Implementation strategy

Specific actions have been identified to assist in achieving vegetation and flora management objectives (Table 12).

**Table 12 Vegetation and flora management actions**

| Parameter | Action |
|---|---|
| Planning | Emergency response procedures will be developed for the following:<br>• outbreaks of fire. |
| | Opportunities to minimise the clearing of vegetation will be investigated and documented. |
| | Clearing will be planned such that areas of elevated conservation significance will be avoided as far as practicable. |
| | Clearing will be planned such that vegetated areas are retained until required ahead of mine development. |
| | Internal authorisations will be obtained prior to commencement of clearing. |
| Clearing controls | Topsoil and subsoil will be stripped prior to commencement of clearing and managed in accordance with relevant procedures. |
| | Clearing will only occur within approval boundaries and limits. |
| | Clearing will avoid areas of elevated conservation significance as far as practicable. Conservation significant areas include the following:<br>• West Angelas Cracking Clay Priority Ecological Community (PEC),<br>• grove / intergrove Mulga communities, and<br>• areas supporting Rare and / or Priority Flora (particularly *Lepidium catapycnon*). |
| | Known locations of Declared Rare Flora, Priority 1 and Priority 2 Flora species will be mapped as an avoidance area within the proponent's internal Approvals Request System to prevent disturbance as far as practicable. |
| | Any proposal to disturb Declared Rare Flora will require consent from the Minister for Environment in the form of a Permit to Take. |
| | Vehicle access will be restricted to designated tracks and roads as far as practicable. |
| Rehabilitation | Where clearing of vegetation is unavoidable, areas will be progressively rehabilitated with local native vegetation where possible. |
| | Seeds from as many native plant species of local provenance as possible will be used for rehabilitation. |
| | Appropriate signage will be erected to advise that rehabilitation is in progress and access is not permitted. |
| | A monitoring program will be established to measure the success of rehabilitation. |
| | Unnecessary disturbance of rehabilitated areas will be avoided. |

| Parameter | Action |
|---|---|
| Phreatophytic species | A monitoring program will be undertaken to assess the impacts of drawdown on phreatophytic vegetation within the Turee Creek "B" Borefield. |
| Mulga | Additional culverts will be incorporated along the rail and access road as appropriate to minimise impacts of drainage shadow on Mulga communities adjacent to the rail line. |
| | A monitoring program will be undertaken to assess the impacts of drainage shadow on the health of Mulga communities adjacent to the rail line within the Coondewanna Flats (shown on Figure 7). |
| Riparian species | A monitoring program will be undertaken to assess the impacts of discharge on riparian vegetation along the discharge creekline. |
| Weed management | The type and abundance of weed species will be internally recorded and monitored. |
| | Monitoring of 'Weed Risk Areas' with high potential for weed invasion, such as along roadsides, recently cleared areas and ephemeral drainage lines will be undertaken. |
| | Weed management will be undertaken as part of an annual weed control program and as otherwise required. Weed management procedures include:<br>• Mechanical (pulling out) and/or chemical (use of selective herbicides) methods to control current weed infestations; and<br>• Spot spraying of emergent weeds to gradually deplete seed stocks and reduce or eliminate any new colonisation.<br>Due to the presence of dormant seeds, weeds are expected to appear over a number of years irrespective of the method of control. |
| | Weed management will be adaptable and able to respond to changing conditions and weed infestations. |
| | Weed hygiene measures will be implemented. Prior to entering site, all ground engaging equipment will be inspected and cleaned of all soil, seeds and vegetative material prior to mobilisation and demobilisation to minimise the risk of introducing and spreading weeds. |
| Fire management | Fire restrictions will be implemented (except for fire training purposes). |
| | Site personnel will be required to complete basic fire-fighting training. |
| | Emergency response (fire fighting) procedures will be developed and implemented. |
| | Appropriate fire fighting equipment will be available in all buildings and vehicles to control localised outbreaks of fire. |
| | Regular inspection and maintenance of fire fighting equipment will be implemented to comply with relevant fire safety standards. |
| Induction | Prior to engagement on site, all staff will be inducted on:<br>• conservation significant vegetation and flora locations and their importance,<br>• the requirement to stay within approved disturbance boundaries,<br>• identification and reporting of weeds,<br>• procedures to minimise the introduction and spread of weeds,<br>• fire hazard awareness and emergency response procedures. |

### 4.3.5 Monitoring program

The monitoring program for vegetation and flora at West Angelas (Table 13) is designed to ensure that operations are consistent with the prescribed management actions. Monitoring will measure the success of these actions in accordance with the management objectives and targets.

**Table 13 Vegetation and flora monitoring program**

| Topic | Frequency | Parameters | Procedure | Purpose |
|---|---|---|---|---|
| Clearing | Annually | Reconciliation of actual clearing against approval boundary and limits | Visual inspection | To manage clearing of vegetation in compliance with all approval requirements. |
| Phreatophytic species | Annually | Foliage condition, dead limbs or other damage, evidence of pests or pathogens etc. as an indicator of tree health | Tree Health Monitoring Programme | To monitor changes in phreatophytic tree health relative to baseline to determine the impact of groundwater drawdown. |
| Conservation significant Mulga | All transects every 3 years or at least two thirds of the transects alternate years | Mulga community health (Mulga under stress or dying) | Drainage Shadow (Mulga) Monitoring Procedure | To monitor changes to the survival and health of Mulga relative to baseline to determine the impact of drainage shadow. |
| Riparian vegetation | Annually | Riparian vegetation community structure, species diversity, cover and abundance | Transect surveys | To monitor changes in riparian vegetation community structure, species diversity, cover and abundance relative to baseline to determine the impact of surface water discharge. |
| Weeds | As required | Soil, seeds and vegetative material on equipment | Visual inspection in accordance with Equipment Hygiene Procedures | To minimise the risk of introducing and spreading weeds. |
| | Annually and as required | Appearance of new weed species and abundance | Visual inspection | Identification of weed risk areas. |
| | Ongoing | Weed species and abundance of known infestations | Visual inspection until monitoring has revealed that the infestation is no longer present. | To monitor the effectiveness of weed management and ensure known infestations are controlled or eradicated. |
| Weed Risk Areas | Opportunistically | Appearance of new weed infestations | Visual inspection | To monitor areas that may act as traps for seeds and provide good conditions for seed germination, and to ensure new weed infestations are controlled immediately. |
| *Groundwater will be monitored and managed as specified in the Groundwater Management Plan.* | | | | |
| *Surface water will be monitored and managed as specified in the Surface Water Management Plan.* | | | | |
| *Dust will be monitored and managed as specified in the Dust Management Plan.* | | | | |

### 4.3.6 Contingencies

Contingency actions have been developed to be enacted if monitoring indicates that the environmental objectives and targets for vegetation and flora management at West Angelas are not being achieved (Table 14).

**Table 14 Vegetation and flora management contingency actions**

| Management objective | Trigger | Action |
|---|---|---|
| To manage clearing of vegetation in compliance with all approval requirements. | Clearing outside approval boundary | 1. Immediately cease clearing.<br>2. Report as Environmental Incident.<br>3. Initiate Incident Response Procedure, including:<br>i. investigate cause of clearing outside approval boundary,<br>ii. notify relevant stakeholders<br>4. Identify remedial actions (e.g. rehabilitation) on advice from relevant stakeholders.<br>5. Implement remedial action as required.<br>6. Review relevant environmental procedures (e.g. West Angelas Land Clearance Procedure).<br>7. Review the need for personnel training (e.g. in West Angelas Land Clearance Procedure). |
| | Area of clearing is greater than approved clearing limit | 1. Immediately cease clearing.<br>2. Report as Environmental Incident.<br>3. Initiate Incident Response Procedure, including:<br>i. investigate cause of clearing outside approved clearing limit,<br>ii. notify relevant stakeholders<br>4. Identify remedial actions (e.g. rehabilitation) on advice from relevant stakeholders.<br>5. Implement remedial action as required.<br>6. Review relevant environmental procedures (e.g. West Angelas Land Clearance Procedure).<br>7. Review the need for personnel training (e.g. in West Angelas Land Clearance Procedure). |

| Management objective | Trigger | Action |
|---|---|---|
| To protect conservation significant vegetation communities and species. | Unauthorised disturbance to known conservation significant vegetation communities and / or species. | 1. Immediately cease clearing.<br>2. Report as Environmental Incident.<br>3. Initiate Incident Response Procedure, including:<br>i. investigate cause,<br>ii. notify relevant stakeholders.<br>4. Identify remedial actions (e.g. rehabilitation) on advice from relevant stakeholders.<br>5. Implement remedial actions as required.<br>6. Review relevant environmental procedures (e.g. West Angelas Land Clearance Procedure).<br>7. Review the need for personnel training (e.g. in West Angelas Land Clearance Procedure). |
| To protect conservation significant vegetation communities and species. | New occurrence(s) of conservation significant vegetation community or species recorded. | 1. Record location of species.<br>2. Investigate opportunities to protect new occurrence(s) of conservation significant vegetation community or species.<br>3. If Declared Rare Flora are found, report the occurrence(s) to the DPaW. If there is a need to disturb them, submit an application for a Licence to Take Threatened (Declared Rare) Flora, for approval by the Minister for the Environment in accordance with the *Wildlife Conservation Act 1950.* |
| | Significant[1] decline of phreatophytic vegetation condition (outside natural variability) for successive monitoring events | 1. Investigate potential cause of decline including;<br>i. review data quality to identify any errors in data, collection or interpretation, anomalous readings etc.,<br>ii. review site and tree condition information to determine the presence of factors likely to cause decline in tree health – e.g. fire or flood damage, evidence of insect activity or pathogens etc.,<br>iii. review seasonal rainfall data and regional groundwater water levels,<br>iv. review groundwater abstraction volumes / rates and extent of drawdown,<br>v. review tree health monitoring results from regional reference sites.<br>2. Increase frequency of monitoring as appropriate.<br>3. If groundwater abstraction is identified as cause and a recovering trend is not evident following the next monitoring;<br>i. notify relevant stakeholders,<br>ii. identify remedial options (e.g. reassess groundwater abstraction volumes / rates, cease pumping, surface irrigation, supplementation and / or rehabilitation) on advice from relevant stakeholders,<br>iii. implement remedial actions as required. |

| Management objective | Trigger | Action |
|---|---|---|
| | Significant[2] decline in Mulga community health (outside natural variability) for successive monitoring events | 1. Investigate potential causes of degradation of vegetation condition including;<br>i. review data quality to identify any errors in data, collection or interpretation, anomalous readings etc.,<br>ii. review site and tree condition information to determine the presence of factors likely to cause degradation – e.g. fire, storm damage etc.,<br>iii. review seasonal rainfall data.<br>2. If drainage management is identified as cause and a recovering trend is not evident following the next monitoring;<br>i. notify relevant stakeholders,<br>ii. identify remedial options (e.g. reassess drainage management systems, surface irrigation, supplementation and / or rehabilitation) on advice from relevant stakeholders,<br>iii. implement remedial actions as required. |
| | Significant[3] decline or artificial proliferation of riparian vegetation community structure, species diversity, cover or abundance (outside natural variability) for successive monitoring events | 1. Investigate potential causes of decline or artificial proliferation of vegetation or degradation of vegetation condition including;<br>i. review data quality to identify any errors in data, collection or interpretation, anomalous readings etc.,<br>ii. review site and vegetation condition information to determine the presence of factors likely to cause foliage loss – e.g. fire, storm damage, insect activity, waterlogging, foliage pathogens etc.,<br>iii. review seasonal rainfall data,<br>iv. review surface water discharge volumes / rates and extent of discharge,<br>v. review vegetation monitoring results from regional reference sites.<br>2. Increase frequency of monitoring as appropriate.<br>3. If surface water discharge is identified as cause and a recovering trend is not evident following the next monitoring;<br>i. notify relevant stakeholders,<br>ii. identify remedial options (e.g. reassess groundwater abstraction volumes / rates, reassess surface water discharge volumes / rates, surface irrigation, supplementation and / or rehabilitation), on advice from relevant stakeholders,<br>iii. implement remedial actions as required. |
| To prevent the displacement of native species by weed species | Introduction of new weed species and / or substantial increase in the abundance of weeds. | 1. Record location and abundance.<br>2. Undertake weed control.<br>3. Review relevant procedures (e.g. vehicle hygiene procedures) and modify as required. |

| Management objective | Trigger | Action |
|---|---|---|
| To ensure that dust emissions do not adversely affect environmental values | Visual dust assessments indicate unacceptable dust levels on vegetation | 1. Investigate potential cause of unacceptable dust levels on vegetation.<br>2. Implement additional dust control measures including, as appropriate:<br>i. increased application of water,<br>ii. application of dust suppressants to vehicle loads and stockpiles.<br>3. Moderate activities generating dust if actions listed under (2) above are inadequate to reduce dust emissions to acceptable levels.<br>4. Identify and implement remedial actions (e.g. rehabilitation, spray vegetation to remove dust particles) as required. |
| To ensure that fire does not adversely affect environmental values | Fire incident. | 1. Respond to fire in accordance with Emergency Response Procedure, including as appropriate:<br>i. immediately extinguish the fire,<br>ii. report as an Environmental Incident.<br>2. Investigate cause of fire.<br>3. If fire was a result of operations, investigate and implement preventative measures to reduce future fire risk.<br>4. Implement remedial actions (e.g. rehabilitate burnt area) as required.<br>5. Review environmental incidents relating to fire.<br>6. Review relevant procedures (e.g. emergency response procedures).<br>7. Review the need for personnel training (e.g. in emergency response procedures). |

[1] Statistical significance based on Student's paired t-test ($p<0.05$) compared to baseline and subsequent tree condition scores.

[2] Statistical significance based on Student's paired t-test ($p<0.05$) compared to baseline and subsequent Mulga health status scores.

[3] Statistical significance based on two-tailed Student's paired t-test ($p<0.05$) compared to baseline and subsequent species diversity, cover and richness.

## 4.4 FAUNA MANAGEMENT PLAN

### 4.4.1 Description

- West Angelas is acknowledged to support diverse fauna for its size due to the variety of relief and geological types which combine to provide a great diversity of habitats. Nine broad-scale habitat types have been identified across the region, largely based on vegetation structure and landform: 'footslope or plain'; 'hilltop, hillslope, ridge or cliff'; 'mixed Acacia woodland'; 'mesa top'; 'cracking clay'; 'major gorge and gully'; 'major drainage'; 'mulga woodland'; and 'cleared area'.
- One of these fauna habitats; the Cracking Clay habitat is considered to be regionally significant. Mulga woodlands also support a diverse fauna assemblage and are also considered regionally significant. The remainder of the fauna habitats represent units that are likely to be widely distributed and relatively well represented in the Hamersley subregion of the Pilbara bioregion.
- A number of species of conservation significance have either been recorded or otherwise are considered to have a moderate to high likelihood of occurrence within the area; Pilbara Leaf-nosed Bat (*Rhinonicteris aurantius*) listed as 'Vulnerable' under the EPBC Act, as a Schedule 1 species under the state WC Act and as 'Vulnerable' by the DPaW; Pilbara Olive Python (XX) listed as 'Vulnerable' under the EPBC Act, as a Schedule 1 species under the state WC Act and as 'Vulnerable' by the DPaW; Fork-tailed Swift (*Apus pacificus*) listed as 'Migratory' under the EPBC Act and as a Schedule 3 species under the WC Act; Rainbow Bee-eater listed as 'Migratory' under the EPBC Act and as a Schedule 3 species under the WC Act; Pilbara Barking Gecko (*Underwoodisaurus seorsus*) listed as P1 species by the DPaW; Western Pebble-mound Mouse (*Pseudomys chapmani*) listed as P4 species by the DPaW; Ghost Bat (*Macroderma gigas*) listed as P4 species by the DPaW; Short-tailed Mouse (*Leggadina lakedownensis*) listed as P4 species by the DPaW; Australian Bustard (*Ardeotis australis*) listed as P4 species by the DPaW; and Bush Stone-curlew (*Burhinus grallarius*), listed as P4 species by the DPaW.
- Ghost Bats have been known from the area since at least 1978. Five caves have been identified as being of value to Ghost Bats: caves A1; A2; L2; and L3 near Deposit B; and a potential maternity cave AA1 near Deposit F (Figure 5).
- A number of feral species have also been recorded within the area.
- The WAO will result in the clearing and potential fragmentation/isolation of habitat for development of mine pits, waste dumps, processing facilities, stockpiles, accommodation, roads, railway and other associated infrastructure.
- The WAO will result in increased human interaction and vehicle/machinery use in the area.
- The WAO will generate domestic waste from the accommodation camp, crib rooms, and administration areas.

### 4.4.2 Environmental aspects to be managed

The potential impacts of the Proposal on fauna values and the causal aspects of the Proposal requiring management are as follows:

- **Habitat disturbance** through vegetation clearing.
- **Habitat disturbance** through blast vibration.
- **Direct impact to individuals** may result from human interaction and vehicle and earth movements.
- **Encouragement of feral animals** through availability of domestic waste.

The management of subterranean fauna is addressed in the Groundwater Management Plan (Section 4.1).

### 4.4.3 Performance management

Environmental targets and performance indicators have been developed based on the fauna management objectives for West Angelas (Table 15).

**Table 15 Fauna management objectives, targets and performance indicators**

| Management objective | Target | Performance indicators |
|---|---|---|
| To protect significant fauna habitats. | Avoid significant fauna habitats. | Reconciliation of actual clearing against approval boundaries. |
| | No impact to fauna habitat outside of the approved disturbance boundaries. | Reconciliation of actual clearing against approval boundaries. |
| To minimise impact to individual native fauna. | Minimise impact on individual native fauna by vehicle/machinery movements. | Incident Reports for native fauna collision. |
| Minimise the effect of feral animals on native fauna. | No substantial increase in feral animal abundance. | Number of feral animals recorded during trapping exercises. |

### 4.4.4 Implementation strategy

Specific actions have been identified to assist in achieving fauna management objectives (Table 16).

**Table 16 Fauna management actions**

| Parameter | Action |
|---|---|
| Protection of significant fauna habitats | Clearing will only occur within approval boundaries. |
| | Clearing will avoid significant fauna habitats as far as practicable. |
| | Sites that are utilised by Ghost Bats will be avoided as far as practicable. |
| | Buffers around sites that are utilised by Ghost Bats will be demarcated and maintained to a minimum of 100 metres where practicable.<br>A 100 metre exclusion zone will be maintained for the potential ghost Bat maternity cave AA1 |
| | Blast vibration control, including vibration risk assessment, controlled blasting and vibration monitoring will be implemented to ensure that sites that are utilised by Ghost Bats are protected. |
| | Appropriate signage will be put in place at sites that are utilised by Ghost Bats. |
| Native fauna protection | The use of barbed wire fences is prohibited, unless a statutory requirement (e.g. *Electricity (Licensing) Regulations 1991*). Where barbed wire is necessary, reflectors will be installed to deter bats. |
| | Pets will be prohibited on the mine site. |
| | Firearms use will be restricted and only after approval is received from the Registered Manager. |
| | Vehicles will be restricted to designated tracks and drivers will abide by the allocated speed limit except in cases of emergency. |
| | Known native fauna 'hot spots' will be sign posted to notify drivers |
| Native fauna encounter | The requirements of the Wildlife Interaction Policy will be communicated to, and implemented by, all personnel. |
| | Native animals encountered on-site will be given the opportunity to move on if there is no threat to personnel safety in doing so. |
| | Snakes will be relocated from work areas by appropriately trained snake-handlers. |
| | If sick or injured animals are encountered, a nominated carer will assess possible rescue and rehabilitation of the animal. |
| | Dead ghost bats will be lodged with the Western Australian Museum. |

| Parameter | Action |
|---|---|
| Feral animal control | Feral animal control measures will be implemented, including:<br>• prohibiting the feeding of feral animals<br>• trapping and eradication programs<br>• effective management of domestic waste. |
| Induction | The induction will include relevant information on:<br>• conservation significant fauna and their importance<br>• conservation significant fauna habitat locations<br>• potential for mine activities to affect fauna and fauna habitat<br>• fauna encounter procedures<br>• feral animal controls<br>• safety issues concerning the Lyssavirus and bats. |

### 4.4.5 Monitoring program

The monitoring program for fauna at West Angelas (Table 17) is designed to ensure that operations are consistent with the prescribed management actions. Monitoring will measure the success of these actions in accordance with the management objectives and targets.

**Table 17 Fauna monitoring program**

| Topic | Frequency | Parameters | Procedure | Purpose |
|---|---|---|---|---|
| Clearing | Annually | Reconciliation of actual clearing against approval boundary | Visual inspection | To manage clearing of fauna habitat in compliance with all approval requirements. |
| Fauna encounter | Opportunistically | Sightings of threatened species | Visual observation in accordance with standard Rio Tinto procedures | To monitor occurrence of threatened species. |
| | Opportunistically | Sightings of feral species | Visual observation and trapping in accordance with standard Rio Tinto procedures | To monitor occurrence of feral species and implement management action if required |
| *Subterranean Fauna will be monitored and managed as specified in the Groundwater Management Plan.* | | | | |

### 4.4.6 Contingencies

Contingency actions have been developed to be enacted if monitoring indicates that the environmental objectives and targets for fauna management at West Angelas are not being achieved (Table 18).

**Table 18 Fauna management contingency actions**

| Management objective | Trigger | Action |
|---|---|---|
| To protect significant fauna habitats | Impact to significant fauna habitat | 1. Immediately cease clearing.<br>2. Report as Environmental Incident.<br>3. Initiate Incident Response Procedure, including:<br>i. investigate cause,<br>ii. notify relevant stakeholders.<br>4. Identify remedial actions (e.g. rehabilitation, restoration of habitat) on advice from relevant stakeholders.<br>5. Implement remedial actions as required.<br>6. Review relevant environmental procedures (e.g. West Angelas Land Clearance Procedure).<br>7. Review the need for personnel training (e.g. West Angelas Land Clearance Procedure). |
| | Impact to fauna habitat outside of the approved disturbance boundaries | 1. Immediately cease clearing.<br>2. Report as Environmental Incident.<br>3. Initiate Incident Response Procedure, including:<br>i. investigate cause<br>ii. notify relevant stakeholders<br>4. Identify remedial actions (e.g. rehabilitation) on advice from relevant stakeholders.<br>5. Implement remedial actions as required.<br>6. Review relevant environmental procedures (e.g. West Angelas Land Clearance Procedure).<br>7. Review the need for personnel training (e.g. in West Angelas Land Clearance Procedure). |
| To minimise impact to individual native fauna | Vehicle collision with native fauna | Measures in accordance with the Wildlife Interaction Policy will be undertaken, including:<br>1. Investigate cause of vehicle collision with native fauna.<br>2. Implement remedial actions (e.g. contacting a nominated carer to assess possible rescue and rehabilitation of the animal) as required.<br>3. Report as an Environmental Incident. |

| Management objective | Trigger | Action |
|---|---|---|
| | Monitoring indicates that threatened species is in decline. | 1. Investigate potential cause of decline of threatened species including;<br>i. review seasonal effects,<br>ii. review vehicle collision records,<br>iii. review feral animal abundance records.<br>2. Notify relevant stakeholders.<br>3. Identify remedial actions (e.g. signage, fencing, feral animal trapping or baiting program) on advice from relevant stakeholders.<br>4. Implement remedial actions as required. |
| Minimise the effect of feral animals on native fauna | Increase in feral animal abundance | 1. Investigate potential cause of increase in feral animal abundance including;<br>i. review seasonal effects,<br>ii. review waste inventory and condition of landfill,<br>iii. review regional feral animal records.<br>2. Notify relevant stakeholders.<br>3. Identify remedial actions (e.g. feral animal trapping or baiting program) on advice from relevant stakeholders.<br>4. Implement remedial actions as required. |

## 4.5 DUST MANAGEMENT PLAN

### 4.5.1 Description

- The major sources resulting in visible dust emissions at West Angelas include:
    - Disturbed ground – in dry, windy conditions, particles can be lifted from disturbed areas;
    - Mining activity – blasting, loading, hauling, crushing, conveying, screening and stockpiling material; and
    - Vehicle activity – heavy mining equipment and light vehicles on unsealed surfaces.
- The likely impacts of dust generation from mining activities will mainly be related to health and safety issues. The nearest sensitive receptor is the West Angelas Village, which is approximately 7 kms from the nearest point of the mining operation.
- Dust can also smother vegetation, leading to a decline in the vegetation condition; however no dust-sensitive vegetation has been identified.
- Water for dust suppression is sourced primarily from dewatering.

### 4.5.2 Environmental aspects to be managed

The following aspects of the operations have been identified as potential sources of dust and require management to ensure dust emissions are minimised:

- **Physical disturbance** (removal of vegetation).
- **Ore processing** (blasting, loading, hauling, crushing, conveying, screening and stockpiling material).
- **Haulage and light traffic** on unsealed roads.

### 4.5.3 Performance management

Environmental targets and performance indicators have been developed based on dust management objectives at West Angelas (Table 19).

**Table 19 Dust management objectives, targets and performance indicators**

| Management objective | Target | Performance indicators |
|---|---|---|
| To manage dust in compliance with all licence requirements. | Maintain compliance with dust related licence conditions | Audit and inspection records. |
| To ensure that dust emissions do not adversely affect health. | No dust related complaints received. | All incidents of dust complaints will be investigated. |
| | No adverse impacts on health as a result of dust generated by WAO. | Ambient dust monitoring data show no unacceptable dust levels. |
| To ensure that dust emissions do not adversely affect environmental values. | All reasonable measures are undertaken to control dust. | Dust suppression equipment is effective. |
| | No adverse impacts on environmental values as a result of dust generated by WAO. | Visual dust assessments show no unacceptable dust levels. |

### 4.5.4 Implementation strategy

Specific actions have been identified to assist in achieving dust management objectives (Table 20).

**Table 20 Dust management actions**

| Parameter | Action |
|---|---|
| Planning | Potential sources of dust emissions will be identified. Health and environmental risks associated with these will be assessed. |
| | Clearing will be planned such that vegetated areas are retained until required ahead of mine development. |
| Minimise ground disturbance (exposure) | Clearing of vegetated areas will be staged in order to minimise the extent of exposed soil. |
| | Disturbed areas will be progressively rehabilitated, where possible, to reduce the extent of exposed soil. |
| Dust suppression | Watering from water tankers and / or other appropriate dust suppression methods will be undertaken at areas prone to dust generation, including:<br>• access road;<br>• haul roads;<br>• active pit areas;<br>• mineral waste and topsoil stockpiles, and<br>• cleared areas, as required. |
| | Crushing and screening facilities will be operated with suitable dust suppression and extraction systems, screens and / or sprays. |
| | The train loadout facility will be fitted with water sprays to reduce dust generation. |
| | Regular housekeeping will be undertaken to prevent an accumulation of material in or around plant facilities that may result in dust. |
| | Dust suppression equipment will be maintained in an efficient operating condition. |
| Vehicle movements | Vehicle access will be restricted to designated tracks and roads as far as practicable. |
| | Vehicle speed limits will be prescribed to reduce dust lift-off from unsealed roads. |
| | High use roads will be sealed where practicable. |
| Induction | Prior to engagement on site, all staff will be inducted on:<br>• potential for mine activities to increase dust generation,<br>• potential effects of dust on health, safety and the environment,<br>• dust suppression procedures. |

### 4.5.5 Monitoring program

The monitoring program for dust at West Angelas (Table 21) is designed to ensure that operations are consistent with the prescribed management actions. Monitoring will measure the success of these actions in accordance with the management objectives and targets.

**Table 21 Dust monitoring program**

| Topic | Frequency | Parameters | Procedure | Purpose |
|---|---|---|---|---|
| Village | 15 minute intervals | PM10 dust levels, wind data | Master Monitoring Schedule | To ensure that emissions are measured and identify any dust issues. |
| Visible airborne dust | Opportunistically | Airborne dust | Visual observations | To determine the effectiveness of dust suppression and identify any dust issues. |
| Dust related complaints | Opportunistically | Dust related complaints received | Visual observations | To identify any dust issues. |

### 4.5.6 Contingencies

Contingency actions have been developed to be enacted if monitoring indicates that the environmental objectives and targets for dust management at West Angelas are not being achieved (Table 22).

**Table 22 Dust management contingency actions**

| Management objective | Trigger | Action |
|---|---|---|
| To manage dust in compliance with all licence requirements. | Non-compliance with dust related licence requirement | 1. Investigate potential cause of non-compliance with dust related licence requirement.<br>2. Report as an Environment Incident.<br>3. Identify remedial actions.<br>4. Implement remedial actions, as required. |
| To ensure that dust emissions do not adversely affect health. | Dust monitoring data indicates dust suppression is not effective. | 1. Investigate potential cause of unacceptable dust levels.<br>2. Identify remedial actions.<br>3. Implement remedial actions, as required.<br>4. If trend persists, consult relevant stakeholders. |
| | Dust related complaint received. | 1. Contact any complainants that have concerns related to dust.<br>2. Maintain contact until such time as the source of the incident is verified and resolved as far as practicable. |
| To ensure that dust emissions do not adversely affect environmental values. | Visual dust assessments indicate unacceptable dust levels on vegetation. | 1. Investigate potential cause of unacceptable dust levels.<br>2. Investigate additional dust control measures (e.g. increased water application).<br>3. Implement additional dust control measures as appropriate.<br>4. Moderate activities generating dust if actions listed under (2) above are inadequate to reduce dust emissions to acceptable levels.<br>5. Identify remedial actions (e.g. rehabilitation, spray vegetation to remove dust particles).<br>6. Implement remedial actions, as required. |

## 4.6 WASTE MANAGEMENT PLAN

### 4.6.1 Description

- Wastes will be generated by the Proposal including:
    - mineral waste;
    - inert and putrescible domestic and industrial wastes;
    - liquid wastes including ablution effluent and wash-down water;
    - hazardous waste including hydrocarbons, chemicals, used oils and greases.
- Bulk quantities of fuel required for operations will be stored in bulk fuel storage facilities on-site. Fuel storage and handling will be in accordance with Australian Standard (AS) 1940 "The storage and handling of flammable and combustible liquids" and/or the *Dangerous Goods Safety (Explosives) Regulations 2007 and their updates.*
- Waste, if inappropriately managed, has the potential to contaminate soils, groundwater and surface water and to attract feral animals.

### 4.6.2 Environmental aspects to be managed

The potential impacts of poor waste management practices are:

- **Inefficient use of resources** through failure to reduce, re-use, recycle or recover waste.
- **Contamination of soils, groundwater and/or surface water** through incorrect waste handling, storage and disposal.
- **Food source for feral animals** through incorrect disposal of general waste.
- **Increased potential risk of fire outbreak** through storage and use of flammable material.

The following aspects have been identified as requiring management to minimise potential contamination of the environment by hydrocarbons:

- **Fuel storage.**
- **Stationary fuel usage** (e.g. generators).

- **Refuelling** of vehicles and machinery.

### 4.6.3 Performance management

Environmental targets and performance indicators have been developed based on waste management objectives at West Angelas (Table 23).

**Table 23 Waste management objectives, targets and performance indicators**

| Management objective | Target | Performance indicators |
|---|---|---|
| To minimise the generation of waste by reducing waste streams and increasing recycling wherever practicable. | Mineral waste used in progressive backfilling of mine pit voids as far as practicable. | Opportunities to backfill mine pit voids investigated and implemented wherever practicable. |
| | To implement the waste management hierarchy. | Opportunities for efficient resource use, waste minimisation and recycling investigated and implemented wherever practicable.<br>Wastes are segregated. |
| To ensure that all wastes are handled, stored, treated and / or disposed of in a manner that minimises the risk to the environment. | Correct handling, storage and/or disposal of wastes.<br>No instances of non-compliance with regulatory requirements or licence conditions. | Audit and inspection records. |
| To protect environmental integrity from waste and contamination. | No contamination of soils, groundwater or surface water. | No evidence of unmanaged contamination.<br>Monitoring data shows no unacceptable changes in groundwater quality.<br>*Also see Groundwater and Surface Water Management Plans.* |

### 4.6.4 Implementation strategy

Specific actions have been identified to assist in achieving waste management objectives (Table 24).

**Table 24 Waste management actions**

| Parameter | Action |
|---|---|
| Planning | Emergency response procedures will be developed for the following:<br>• unplanned discharges; and<br>• significant spills. |
| | An inventory of wastes generated, handled and disposed of on-site and off-site will be developed and maintained. |
| | Assessment of the environmental risks associated with wastes generated and disposed of on-site will be developed and maintained. |
| | On-site waste storage, treatment and disposal facilities will be inspected on a regular basis to ensure compliance. |
| Mineral waste | Mineral waste will be used in progressive backfilling of mine pit voids to above the natural ground water level as far as practicable. |
| | The design (height and slope) of mineral waste dumps will consider:<br>• minimisation of dump height,<br>• shaping of dumps to blend in with the surrounding natural topography,<br>• construction to meet the requirements of the final rehabilitation design, and<br>• drainage and erosion management features. |
| | Mineral waste dumps located near drainage features will be monitored to assess for scouring and erosion. Rock armouring, or other stabilising material will be utilised if necessary. |
| Domestic and industrial waste | Waste generation will be minimised through the adoption of the waste management hierarchy (reduce, reuse, recycle) where practicable. |
| | Management of domestic and industrial waste will include:<br>• waste segregation,<br>• burning of waste will be prohibited, and<br>• sufficient number and appropriate placement of bins. |
| | The following will be disposed of at landfill facilities, which will be managed in accordance with licences and appropriate landfill guidelines:<br>• putrescibles (food scraps);<br>• biodegradables (e.g. paper, cardboard);<br>• inert materials (e.g. concrete, steel, wood); and<br>• other general rubbish (e.g. plastics). |
| | The landfill will be fenced and backfilled on a regular basis to prevent wind-blown litter and feral animal foraging. |

| Parameter | Action |
|---|---|
| Waste water | Potentially contaminated water will be excluded from natural surface water systems. |
| | Management measures to exclude contaminants from entering natural surface water systems include:<br>• equipment servicing will take place in workshops wherever possible,<br>• all mechanical equipment washdown will occur on impervious pads, |
| | Waste water collected on-site will be contained to allow treatment prior to re-use or discharge. |
| | Waste water will be directed to a sediment trap or sedimentation basin to reduce suspended solid loading. |
| | Where applicable, hydrocarbons will be removed from waste water via oily water separation facilities. |
| | Waste water treatment facilities will be routinely inspected and maintained to ensure they remain effective. |
| Ablution effluent | Ablution effluent will be managed via appropriately licenced wastewater treatment facilities. |
| | Wastewater treatment facilities will be routinely maintained. |
| | Effluent from the wastewater treatment plant (WWTP) will be discharged within designated irrigation area. |
| Hazardous waste | An inventory of hazardous materials on-site will be maintained. |
| | Hazardous waste materials will be segregated from the general waste stream. |
| | Hazardous waste materials will be collected as required by appropriately licenced controlled waste contractors for offsite disposal. |
| | Assessments of contractors and facilities will be undertaken to ensure that wastes sent off site for disposal or treatment are appropriately dealt with. |
| | Appropriate spill response equipment will be located nearby to work areas where hazardous materials are frequently used, such that it is available for immediate use. |
| Hydrocarbons | Hydrocarbons will be handled, stored and disposed of in accordance with all legal requirements. |
| | Hydrocarbon storage facilities and all associated connections will be within appropriately bunded areas. |
| | Hydrocarbon storage facilities and bunds will be inspected on a regular basis to identify any leaks or maintenance requirements. |
| | Water potentially containing hydrocarbons (exceeding licence criteria) will be contained on-site. |
| | Any hydrocarbon contaminated soil will be remediated and/or disposed of as appropriate. |
| | Hydrocarbon waste materials not suitable for onsite disposal will be collected as required by appropriately licenced controlled waste contractors for offsite disposal or recycling. |
| Spill response | All leaks and spills will be managed in accordance with the requirements of spill response procedures. |
| | Significant spills will be managed in accordance with emergency response procedures. |
| | Personnel that regularly work with hydrocarbons will be trained in the requirements for spill response. |
| | Appropriate spill response equipment will be located nearby to work areas such that it is available for immediate use. |

| Parameter | Action |
|---|---|
| Induction | Prior to engagement on site, all staff will be inducted on:<br>• principles of waste minimisation,<br>• waste management,<br>• potential impacts associated with waste generated,<br>• storage and handling of hydrocarbons/chemicals, and<br>• spill response procedures. |
| | Personnel involved with hazardous materials handling, storage and disposal will be made aware of the associated risks to the environment and will be appropriately trained in emergency response. |

### 4.6.5 Monitoring program

The monitoring program for waste at West Angelas (Table 25) is designed to ensure that operations are consistent with the prescribed management actions. Monitoring will measure the success of these actions in accordance with the management objectives and targets.

**Table 25 Waste monitoring program**

| Topic | Frequency | Parameters | Procedure | Purpose |
|---|---|---|---|---|
| Waste inventory | Quarterly | Waste inventory is complete and accurate | Visual observation | To ensure all wastes have been recorded. |
| | Ongoing | Volume of waste | Visual observation; waste contractor inventory reports | To identify opportunities to minimise the generation of waste. |
| Waste dumps | Opportunistically | Design | Visual observation | To ensure that waste dumps comply with design criteria. |
| On-site waste facilities | Opportunistically | Design and condition of on-site waste facilities | Visual observation | To ensure effective function and condition of all on-site waste facilities. |
| | Opportunistically | Contents of on-site waste facilities | Visual observation | To ensure on-site waste facilities contain only wastes in the category designated for that facility. |
| | Opportunistically | Litter/rubbish | Visual observation | To ensure all domestic and industrial wastes are disposed of properly. |
| | Opportunistically | Hazardous materials segregated appropriately | Visual observation | To prevent incidents from the storage of incompatible substances e.g. fire, explosion. |
| WWTP discharge water quality | Ongoing | Volume of wastewater discharged | Water quality sampling and analysis as per the West Angelas Operating Licence | To track cumulative discharge volumes and ensure compliance with licence conditions. |
| | Quarterly | BOD, TSS, pH, Total P, Total N, *E.coli,* | Water quality sampling and analysis as per the West Angelas Operating Licence | To ensure effective function of the WWTP and ensure water quality does not exceed discharge criteria. |
| Contamination | Opportunistically | Spills, leaks or other evidence of unmanaged contamination | Visual observation | To identify unmanaged leaks and spills. |
| | Quarterly | TPH in surface water | Water quality sampling and analysis (as per the Part V operating licence) | To ensure surface water quality is not compromised. |

| Topic | Frequency | Parameters | Procedure | Purpose |
|---|---|---|---|---|
| | Quarterly | Groundwater quality – TPH, Na, K, Ca, Mg, Cl, $CO_3$, $HCO_3$, $SO_4$, $NO_3$, Metals, TSS, Total-N and Total P | Water quality sampling and analysis (as per the Part V operating licence and Groundwater Operating Strategy) | To ensure groundwater quality is not compromised. |
| Spill response equipment | Opportunistically | Location and and condition of spill response equipment | Visual observation | To ensure appropriate spill response equipment present, stored correctly, and in good order at all times. |

### 4.6.6 Contingencies

Contingency actions have been developed to be enacted if monitoring indicates that the environmental objectives and targets for waste management at West Angelas are not being achieved (Table 26).

**Table 26 Waste management contingency actions**

| Management objective | Trigger | Action |
|---|---|---|
| To minimise the generation of waste by reducing waste streams and recycling material wherever practicable. | Volume of disposed non-recyclable wastes has exceeded the previous volume for consecutive records | 1. Investigate cause of increase in volume of disposed non-recyclable wastes.<br>2. Review waste inventory to identify opportunities to minimise waste generation. |
| To ensure that all wastes are handled, stored, treated and / or disposed of in a manner that minimises the risk to the environment. | Incorrect disposal of waste | 1. Report as an Environmental Incident.<br>2. Implement remedial actions, including correct disposal of wastes and re-informing personnel of correct disposal procedures as required.<br>3. Review environmental incidents relating to incorrect disposal of wastes.<br>4. Review relevant environmental procedures (e.g. disposal procedures).<br>5. Review the need for personnel training (e.g. in correct disposal procedures). |
| | Bins or waste facilities overflowing | 1. Arrange for more frequent waste collection and / or larger receptacles.<br>2. Review waste inventory to identify opportunities to reduce waste generation. |
| | Spill | 1. Mitigate (initiate spill response procedures) including:<br>i. control the spill,<br>ii. contain the spill,<br>iii. clean up the spill, and<br>iv. report the spill as an Environmental Incident.<br>2. Investigate cause.<br>3. Implement remedial actions (e.g. remove any contaminated soil for remediation or disposal) as required.<br>4. Review environmental incidents relating to spills.<br>5. Review relevant environmental procedures (e.g. spill response procedures).<br>6. Review the need for personnel training (e.g. in spill response procedures). |

| Management objective | Trigger | Action |
|---|---|---|
| To protect environmental integrity from waste and contamination | Natural surface water quality adversely affected by wastewater discharge | 1. Immediately decrease or cease discharge (e.g. by temporary storage).<br>2. Report as an Environmental Incident.<br>3. Investigate cause.<br>i. if cause is a is a breakdown in WWTP then initiate repairs as appropriate,<br>ii. if cause is overloading of WWTP then initiate upgrade of plant capacity as appropriate.<br>4. Implement remedial actions as required. |
| | Groundwater or surface water quality adversely affected by a spill | 1. Mitigate (initiate spill response procedures) including:<br>i. control the spill,<br>ii. contain the spill,<br>iii. clean up the spill, and<br>iv. report the spill as an Environmental Incident.<br>2. Investigate cause.<br>3. Implement remedial actions as required.<br>4. Review environmental incidents relating to spills.<br>5. Review relevant environmental procedures (e.g. spill response procedures).<br>6. Review the need for personnel training (e.g. in spill response procedures). |

## 4.7 RAIL MANAGEMENT PLAN

### 4.7.1 Description

- The original proposed rail alignment is fully described in the Environmental Review and Management Plan (1998).
- The rail alignment in the original Proposal commenced at West Angelas and continued north-west, generally following the alignment of the existing Hamersley rail to the intersection with the Pannawonica – Cape Lambert railway. Some sections of the rail line deviated from the Hamersley rail alignment (mostly due to tenure considerations):
    - The original proposed rail alignment, from where it passed Juna Downs (Juna Downs Pass), initially followed the existing Hamersley (Marandoo) rail corridor through Karijini National Park, before it deviated around Eagle Siding. It then re-aligned with the existing Hamersley rail line before striking north from the Marandoo line east of Cockatoo Siding along the Four Corners Bore Route. The Four Corners Bore Route traversed through a Threatened Ecological Community (TEC) (*Themeda* grasslands of the Pilbara bioregion) that was identified following approval of the original Proposal. The rail then deviated northwest to meet up with the Hamersley Paraburdoo – Dampier rail line north of Possum Siding (North Possum).
- Duplication of the existing Hamersley rail from west of Rosella Siding to east of Eagle Siding was approved in February 2009 (instead of implementing the rail line as described in the original Proposal). These deviations involve:
    - Duplicating the existing rail line through Eagle Siding (rather than the construction of a new rail line across undisturbed terrain).
    - Duplicating the existing rail line from Rosella to Cockatoo (rather than constructing a new rail line between East Cockatoo and North Possum (Four Corners Bore Route) across undisturbed terrain, including the TEC, *Themeda* grasslands of the Pilbara bioregion).
    - Construction of a train refuge to the west of Rosella, parallel to the Brockman line, to allow safe and efficient utilisation of the proposed duplication through parking up of trains.
- The rail, from Juna Downs Pass to Rosella Siding, including the deviations described above, has not been implemented.
- The rail, as approved, is shown on Figure 8.

### 4.7.2 Environmental aspects to be managed

The potential impacts of the rail on environmental values requiring management are as follows:

- **Alteration natural surface water drainage patterns** as a result of the rail.
- **Decline of Mulga community health** (outside natural variability) as a result of alteration of existing surface water drainage patterns (drainage shadow).
- **Introduction or spread of weed species** by vehicle and human movements.
- **Contamination of soils, groundwater and/or surface** water through hydrocarbon spills and leaks.
- **Dust generation** could potentially result in the degradation of vegetation condition.

### 4.7.3 Performance management

Environmental targets and performance indicators have been developed based on rail management objectives at West Angelas (Table 27).

**Table 27 Rail management objectives, targets and performance indicators**

| Management objective | Target | Performance indicators |
|---|---|---|
| Maintain the rail drainage system to minimise the effect on the existing local hydrological regime. | No significant change in local surface water drainage patterns (outside natural variability). | Visual inspections show no unacceptable changes in natural drainage patterns, surface water flows are maintained.<br>*Also see Surface Water Management Plan.* |
| To preserve the environmental values of the dependent ecology. | No significant decline in Mulga community health (outside natural variability) as a result of drainage shadow. | Reconciliation of Mulga monitoring data against baseline data.<br>*Also see Vegetation and Flora Management Plan.* |
| To prevent the displacement of native species by weed species. | No increase in the type or abundance of weeds, particularly along sections of the rail within Millstream-Chichester and Karijini National Park Corridors. | Reconciliation of identified weed species / abundance against baseline data.<br>*Also see Vegetation and Flora Management Plan.* |
| Operate the railway to minimise the risk of contamination. | No contamination of soils, groundwater or surface water as a result of rail operations. | No evidence of un-managed spills or leaks (spills cleaned up on occurrence).<br>Monitoring data shows no unacceptable changes in groundwater or surface water quality.<br>*Also see Waste Management Plans.* |

### 4.7.4 Implementation strategy

Specific actions have been identified to assist in achieving rail management objectives (Table 28).

**Table 28 Rail management actions**

| Parameter | Action |
|---|---|
| Drainage management and Mulga | Culverts will be used where appropriate to minimise impacts on natural surface water flows. |
| | Additional culverts will be incorporated along the rail as appropriate to minimise impacts of drainage shadow on Mulga communities adjacent to the rail line. |
| | Culverts will be routinely inspected and maintained to ensure they remain effective. |
| | Monitoring will be undertaken to assess the impacts of drainage shadow on Mulga communities adjacent to the rail line.<br>*See Vegetation and Flora Management Plan.* |
| Weed management | The type and abundance of weed species along the rail will be internally recorded and monitored. |
| | Weed management will be undertaken as part of an annual weed control program and as otherwise required.<br>*See Vegetation and Flora Management Plan.* |
| | Weed management will be adaptable and able to respond to changing conditions and weed infestations. |
| Dust Suppression | The train loadout facility will be fitted with water sprays to reduce dust generation. |
| | Dust suppression equipment will be maintained in an efficient operating condition. |
| Hydrocarbons and spill response | All leaks and spills will be managed in accordance with spill response procedures. |
| | Significant spills will be managed in accordance with emergency response procedures. |
| | Personnel will be trained in the requirements for spill response |
| | Appropriate spill response equipment will be available for immediate use. |
| | Any hydrocarbon contaminated soil will be remediated or disposed of as appropriate. |
| Induction | Prior to engagement on site, all staff will be inducted on:<br>• identification and reporting of weeds,<br>• procedures to minimise the introduction and spread of weeds,<br>• potential for rail activities to increase dust generation,<br>• potential effects of dust on health, safety and the environment,<br>• dust suppression procedures,<br>• waste management, and<br>• spill response procedures |

### 4.7.5 Monitoring program

The monitoring program for the rail at West Angelas (Table 29) is designed to ensure that operations are consistent with the prescribed management actions. Monitoring will measure the success of these actions in accordance with the management objectives and targets.

**Table 29 Rail monitoring program**

| Topic | Frequency | Parameters | Procedure | Purpose |
|---|---|---|---|---|
| Drainage management system | Opportunistically | Surface water flows are maintained | Visual inspection | To monitor the effectiveness of the drainage management system |
| | Opportunistically | Integrity of drainage management system | Visual inspection | To monitor the integrity of the drainage management system. |
| Conservation significant Mulga | All transects every 3 years or at least two thirds of the transects alternate years | Mulga community health (Mulga under stress or dying) | Drainage Shadow (Mulga) Monitoring Procedure | To monitor changes to the survival and health of Mulga relative to baseline to determine the impact of drainage shadow. |
| Weeds in the rail corridor | Annually and as required | Appearance of new weed species and abundance | Visual inspection | Identification of weed risk areas. |
| | Ongoing | Weed species and abundance of known infestations | Visual inspection | To monitor the effectiveness of weed management and ensure known infestations are eradicated. |
| Contamination | Opportunistically | Spills, leaks or other evidence of unmanaged contamination | Visual observation | To identify unmanaged leaks and spills. |

*Dust will be monitored and managed as specified in the Dust Management Plan.*

### 4.7.6 Contingencies

Contingency actions have been developed to be enacted if monitoring indicates that the environmental objectives and targets for rail management at West Angelas are not being achieved (Table 30).

**Table 30 Rail management contingency actions**

| Management objective | Trigger | Action |
|---|---|---|
| Maintain the rail drainage system to minimise the effect on the existing local hydrological regime. | Surface water flows not maintained | 1. Investigate cause.<br>2. Implement remedial actions (e.g. reinstate surface water flows) as required. |
| | Integrity of drainage management system compromised | 1. Investigate cause.<br>2. Undertake maintenance of on-site drainage management system as required.<br>3. Implement remedial actions as required. |
| To preserve the environmental values of the dependent ecology | Significant[2] decline in Mulga community health (outside natural variability) for successive monitoring events | 1. Investigate potential causes of degradation of vegetation condition including;<br>i. review data quality to identify any errors in data, collection or interpretation, anomalous readings etc.,<br>ii. review site and tree condition information to determine the presence of factors likely to cause degradation – e.g. fire, storm damage etc.,<br>iii. review seasonal rainfall data.<br>2. If drainage management is identified as cause and a recovering trend is not evident following the next monitoring;<br>i. notify relevant stakeholders,<br>ii. identify remedial options (e.g. reassess drainage management systems, surface irrigation, supplementation and / or rehabilitation) on advice from relevant stakeholders,<br>iii. implement remedial actions as required. |
| To prevent the displacement of native species by weed species. | Introduction of new weed species and / or significant increase in the abundance of weeds. | 1. Record location and abundance.<br>2. Undertake weed control.<br>3. Review relevant procedures (e.g. vehicle hygiene procedures) and modify as required. |

| Management objective | Trigger | Action |
|---|---|---|
| Operate the railway to minimise the risk of contamination. | Spill | 1. Mitigate (initiate spill response procedures) including:<br>i. control the spill,<br>ii. contain the spill,<br>iii. clean up the spill, and<br>iv. report the spill as an Environmental Incident.<br>2. Investigate cause.<br>3. Implement remedial actions (e.g. remove any contaminated soil for remediation or disposal) as required.<br>4. Review environmental incidents relating to spills.<br>5. Review relevant environmental procedures (e.g. spill response procedures).<br>6. Review the need for personnel training (e.g. in spill response procedures). |

# 5 ACRONYMS AND ABBREVIATION

Table 31 details the short titles and acronyms used in this document.

**Table 31 Acronyms and abbreviations**

| Acronym / Abbreviation | Full title |
|---|---|
| ANZECC | Australia and New Zealand Conservation Council |
| ARMCANZ | Agricultural and Resource Management Council of Australia and New Zealand |
| BOD | Biochemical Oxygen Demand |
| CEO | Chief Executive Officer |
| DCCEE | Department of Climate Change and Energy Efficiency |
| DPaW | Department of Parks and Wildlife |
| DER | Department of Environment Regulation |
| DMP | Department of Mines and Petroleum |
| DoW | Department of Water |
| DRF | Declared Rare Flora |
| DoE | Department of Environment |
| EC | Electrical conductivity |
| EMP | Environmental Management Program |
| EP Act | *Environmental Protection Act 1986 (WA)* |
| EPA | Environmental Protection Authority |
| EPBC Act | *Environment Protection and Biodiversity Conservation Act 1999* |
| ERMP | Environmental Review and Management Plan |
| HSEQ | Health Safety Environment and Quality |
| OEPA | Office of the Environmental Protection Authority |
| TDS | Total dissolved solids |

| Acronym / Abbreviation | Full title |
|---|---|
| TPH | Total petroleum hydrocarbons |
| TSS | Total suspended solids |

Table 32 details the water quality monitoring parameters used in this document.

**Table 32 Water quality monitoring parameters**

| Parameter class | Ground water Parameter(s) | Surface water Parameter(s) |
|---|---|---|
| Biophysical | EC, pH, temperature, TSS<br>water level elevation, abstraction volume | EC, pH, temperature, TSS<br>discharge volume, extent of saturation |
| Nutrients | Total-P, Total-N | n/a |
| Major ions | Na, K, Ca, Mg, Cl, $CO_3$, $HCO_3$, $SO_4$, $NO_3$ | Na, K, Ca, Mg, Cl, $CO_3$, $HCO_3$, $SO_4$, $NO_3$, $NH_3$ |
| Metals and metalloids | Al, Bo, Fe, Cu, Zn, Ag, As, Cr, Pb, Cd, Hg, Ni, Se, Mn. | Al, Bo, Fe, Cu, Zn, Ag, As, Cr, Pb, Cd, Hg, Ni, Se, Mn. |
| Oils and lubricants | Total petroleum hydrocarbons (range $C_6$-$C_{36}$) | Total petroleum hydrocarbons (range $C_6$-$C_{36}$) |

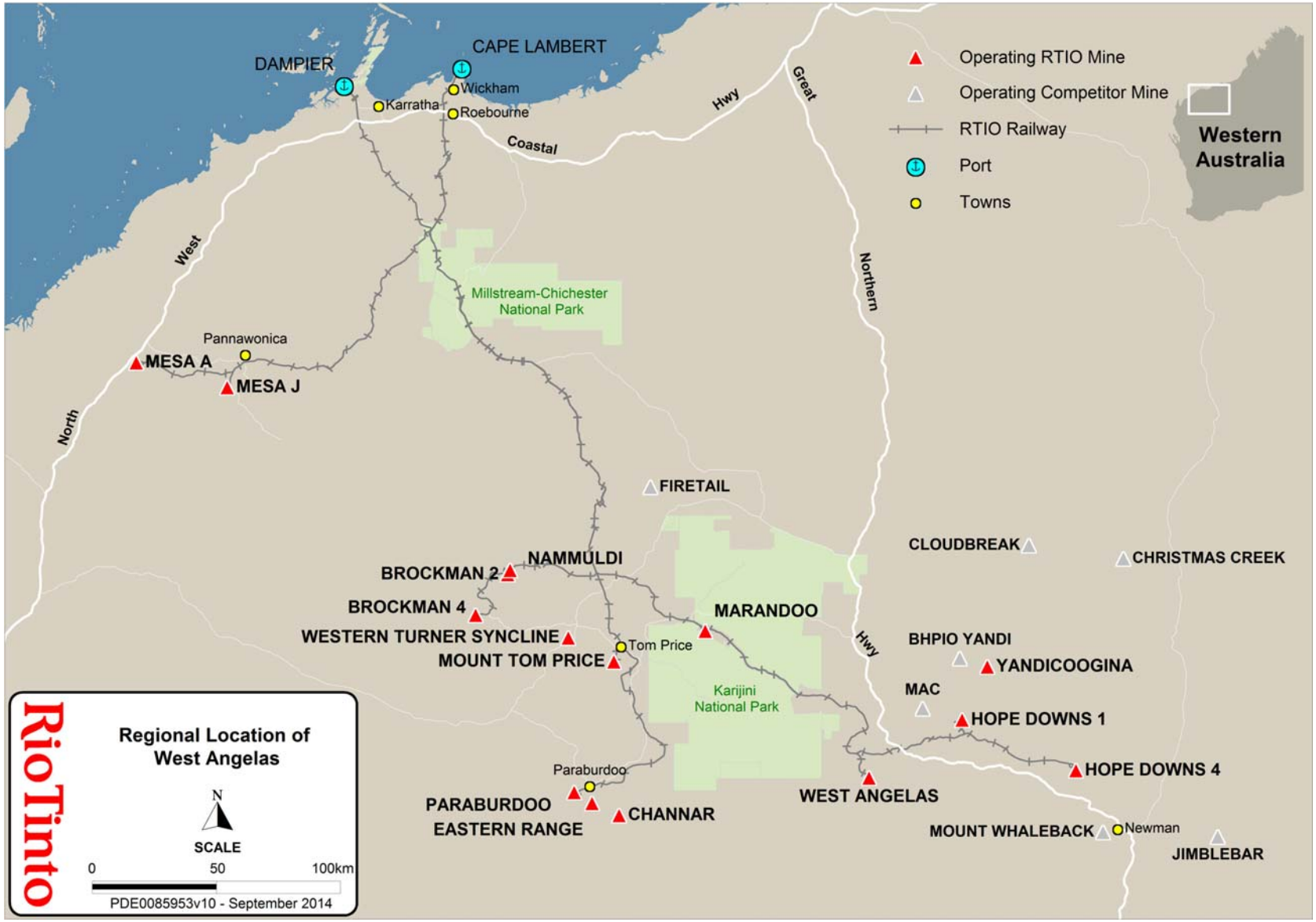


**Figure 1 Regional location of West Angelas**

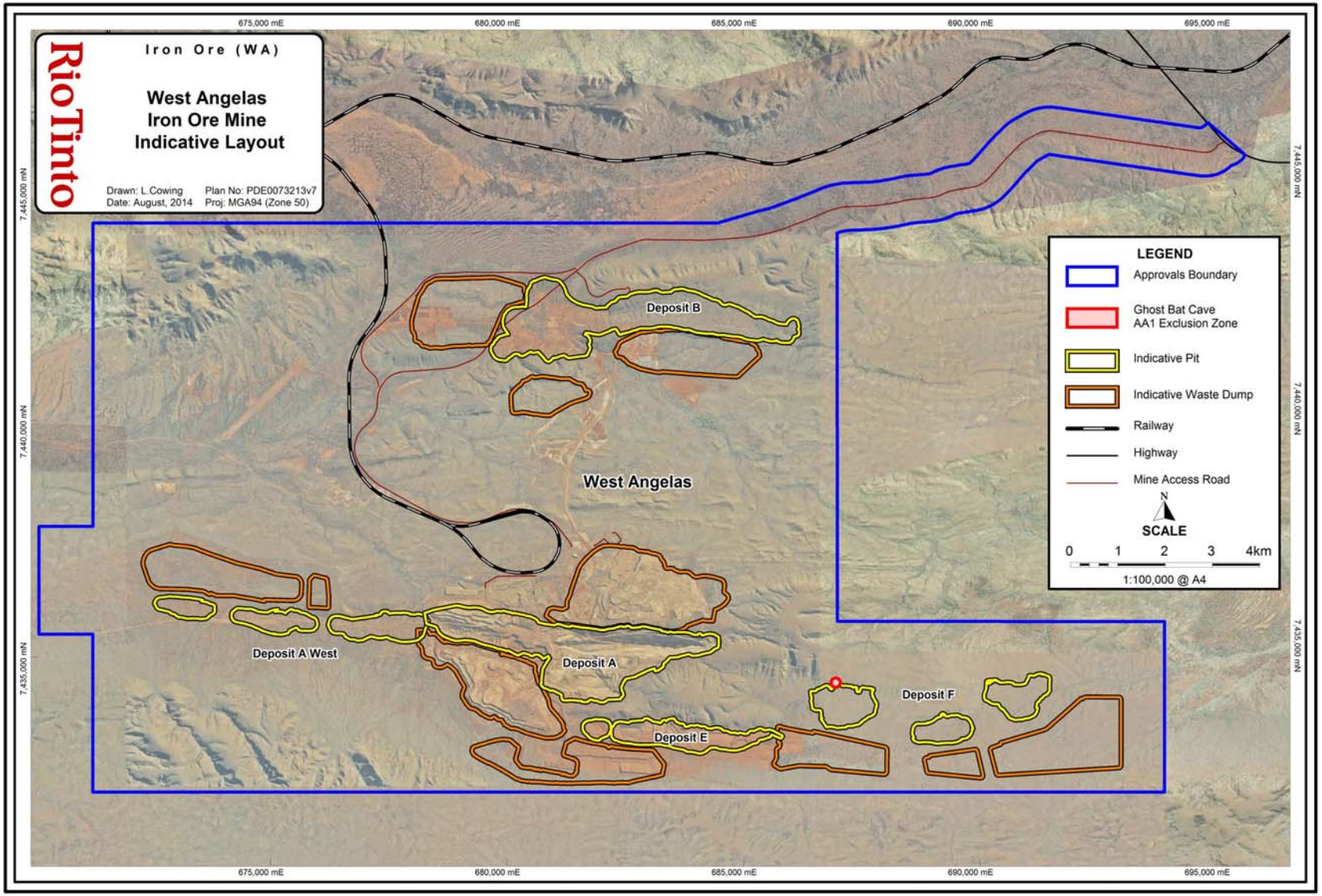


**Figure 2 West Angelas Iron Ore Mine, Indicative Layout**

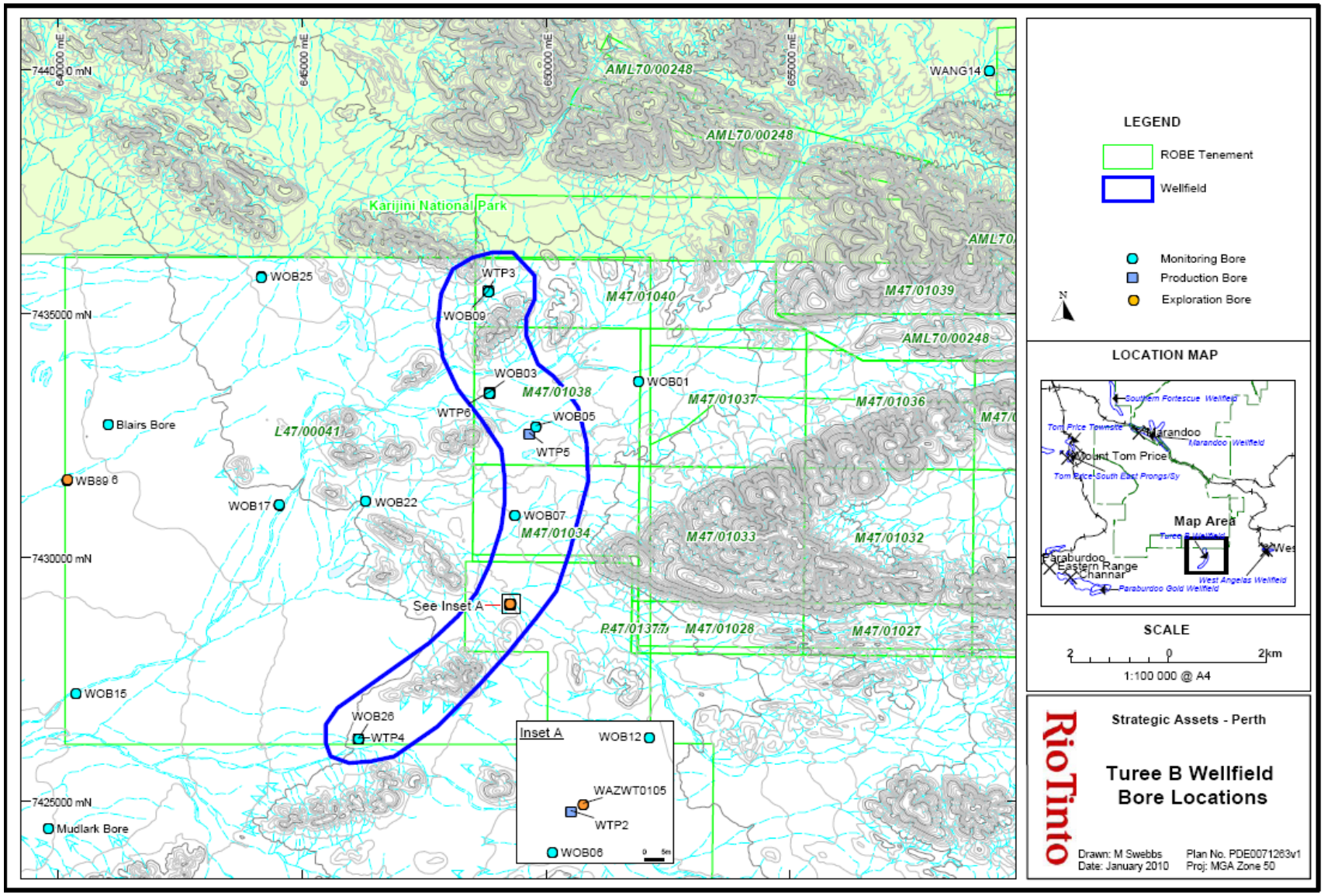


**Figure 3 Turee Creek "B" Borefield, Bore Locations**

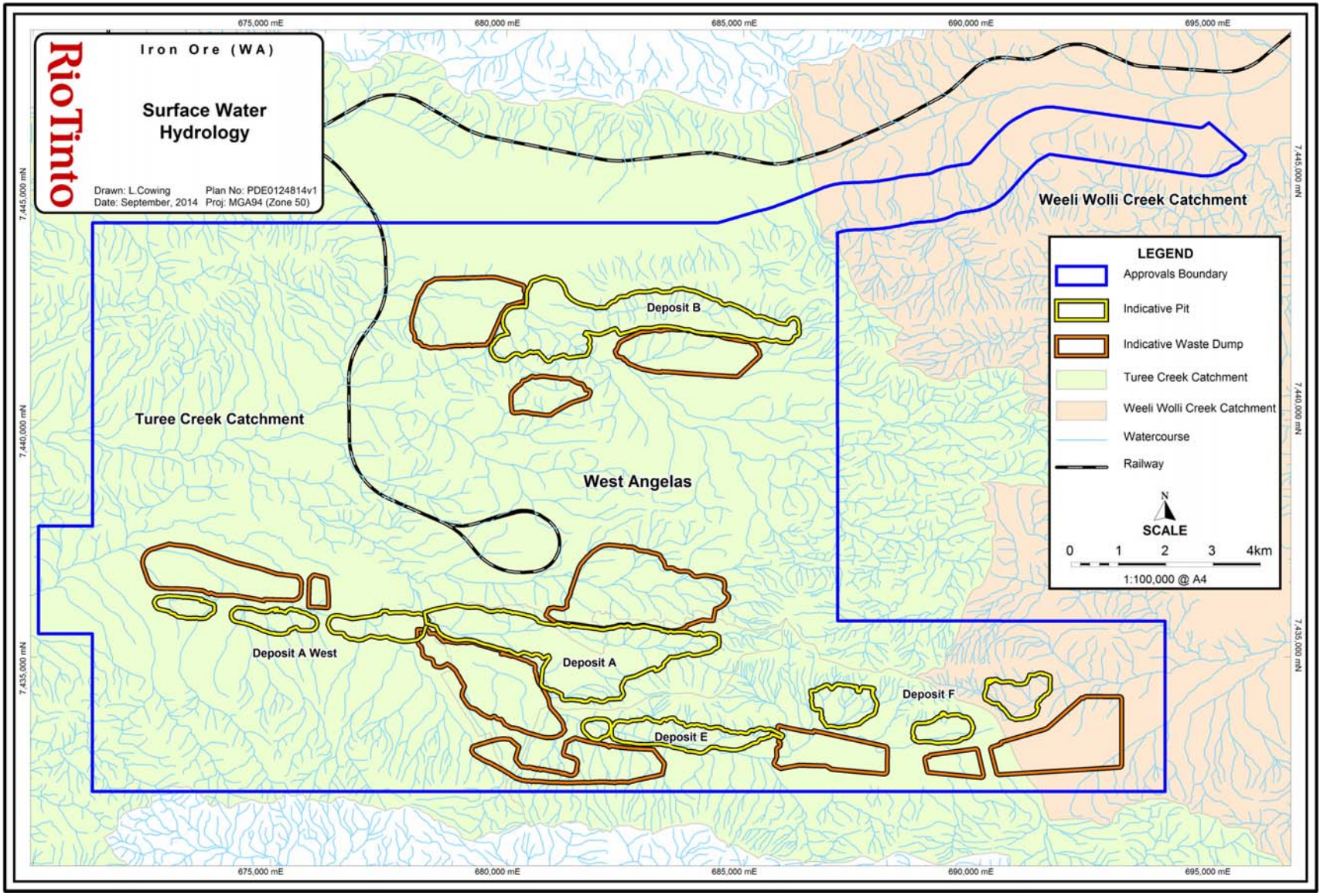


**Figure 4 Surface Water Hydrology**

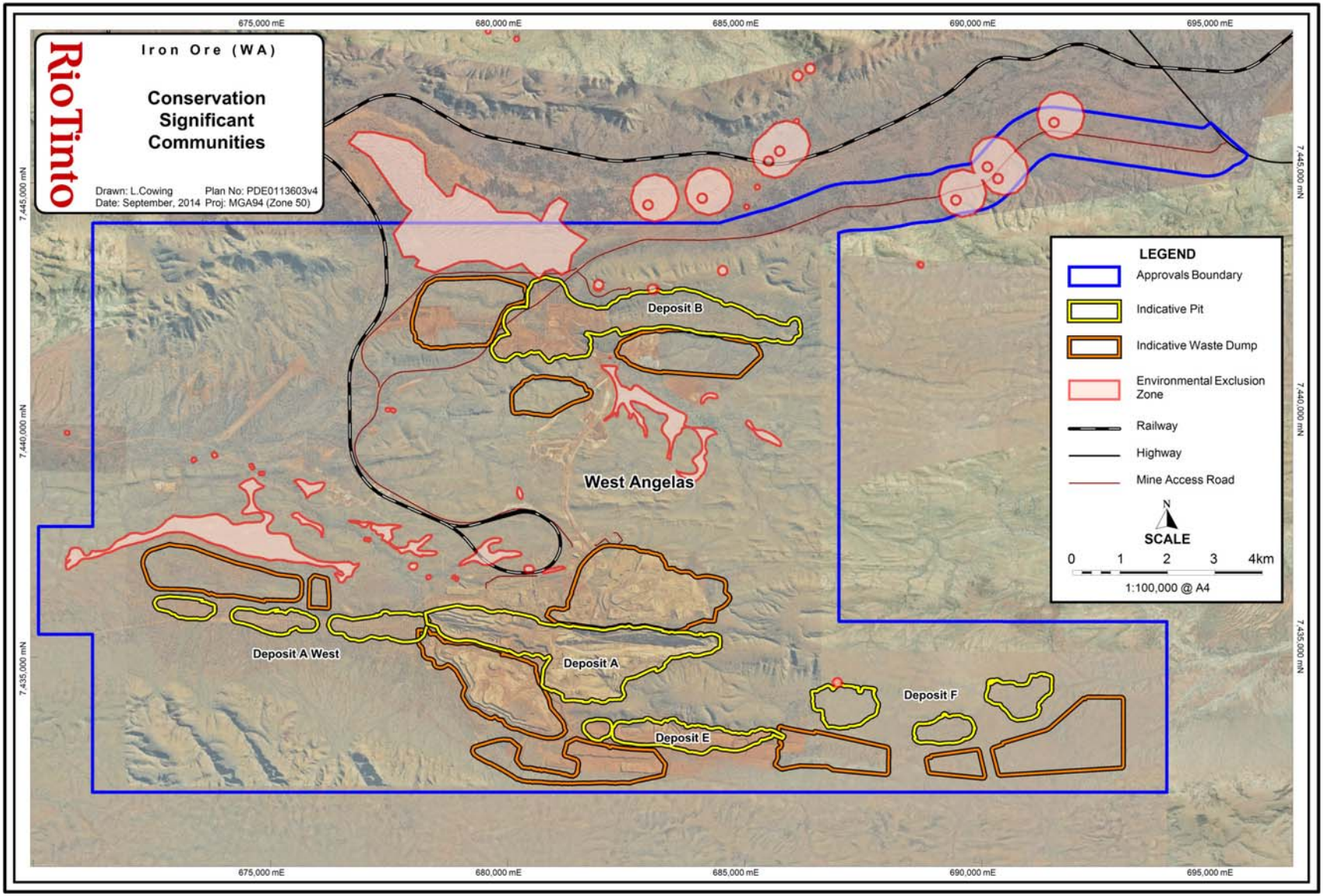


**Figure 5 Location of Conservation Significant Communities and Areas**

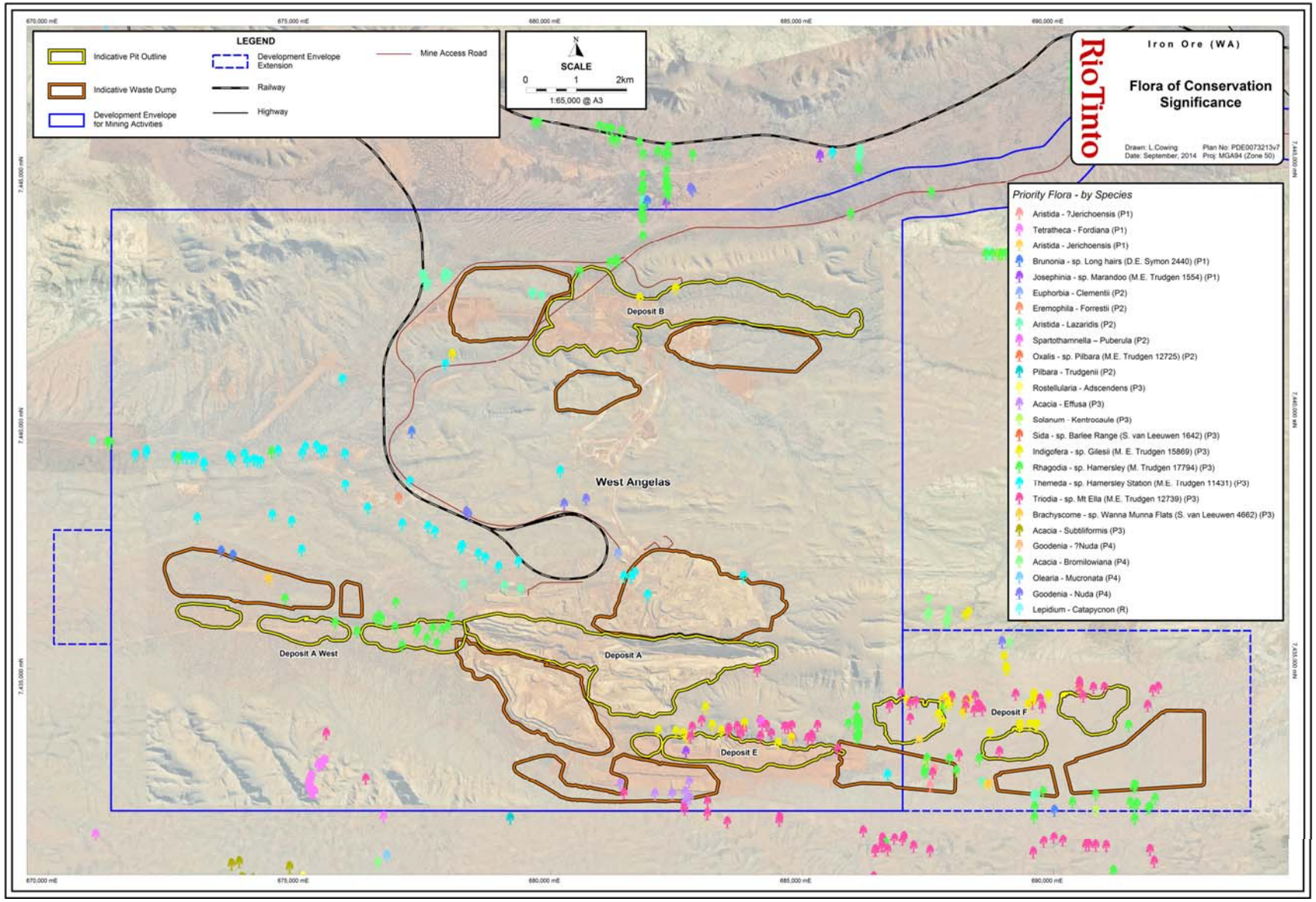


**Figure 6 Flora of Conservation Significance**

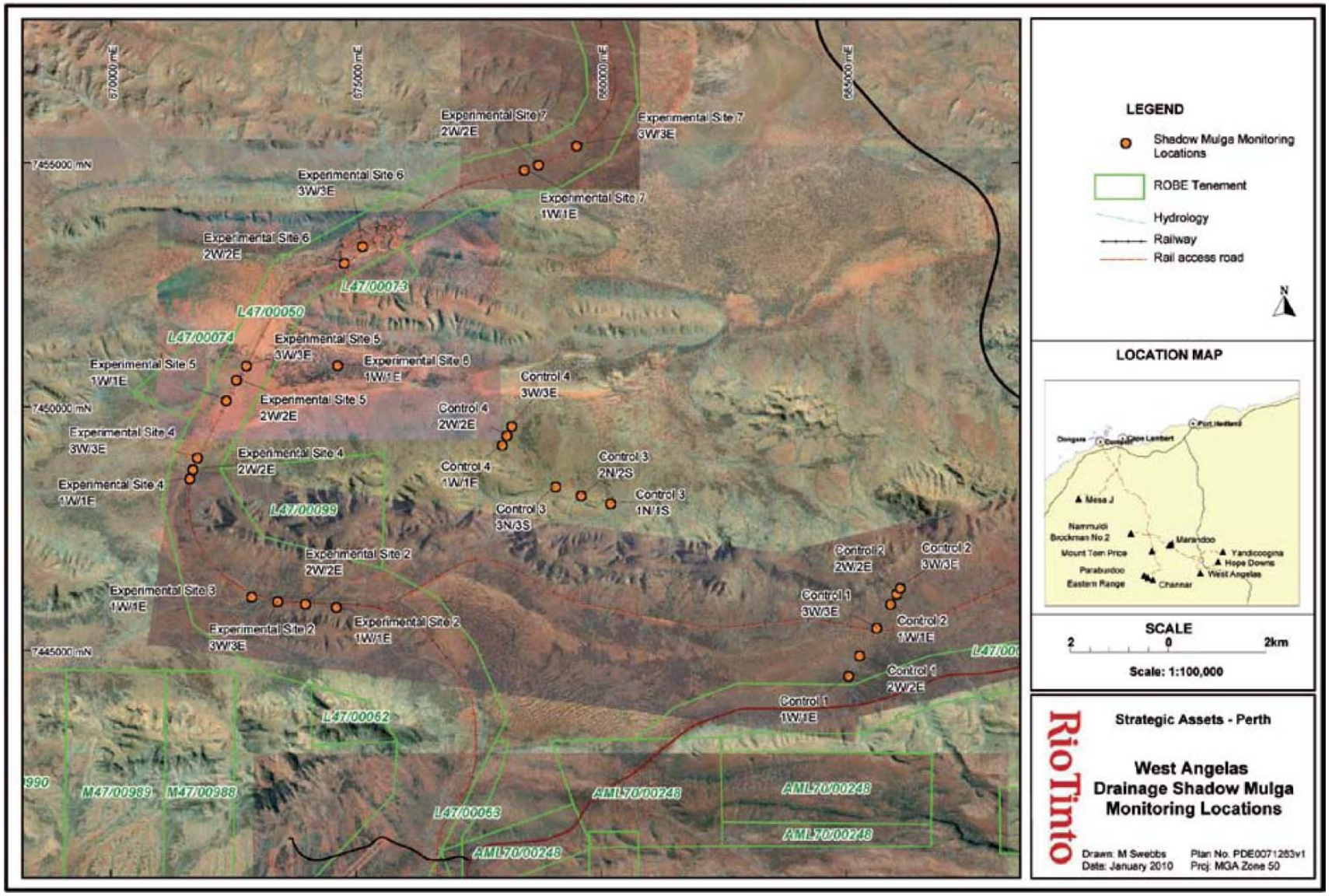


**Figure 7 Drainage Shadow Mulga Monitoring Locations**

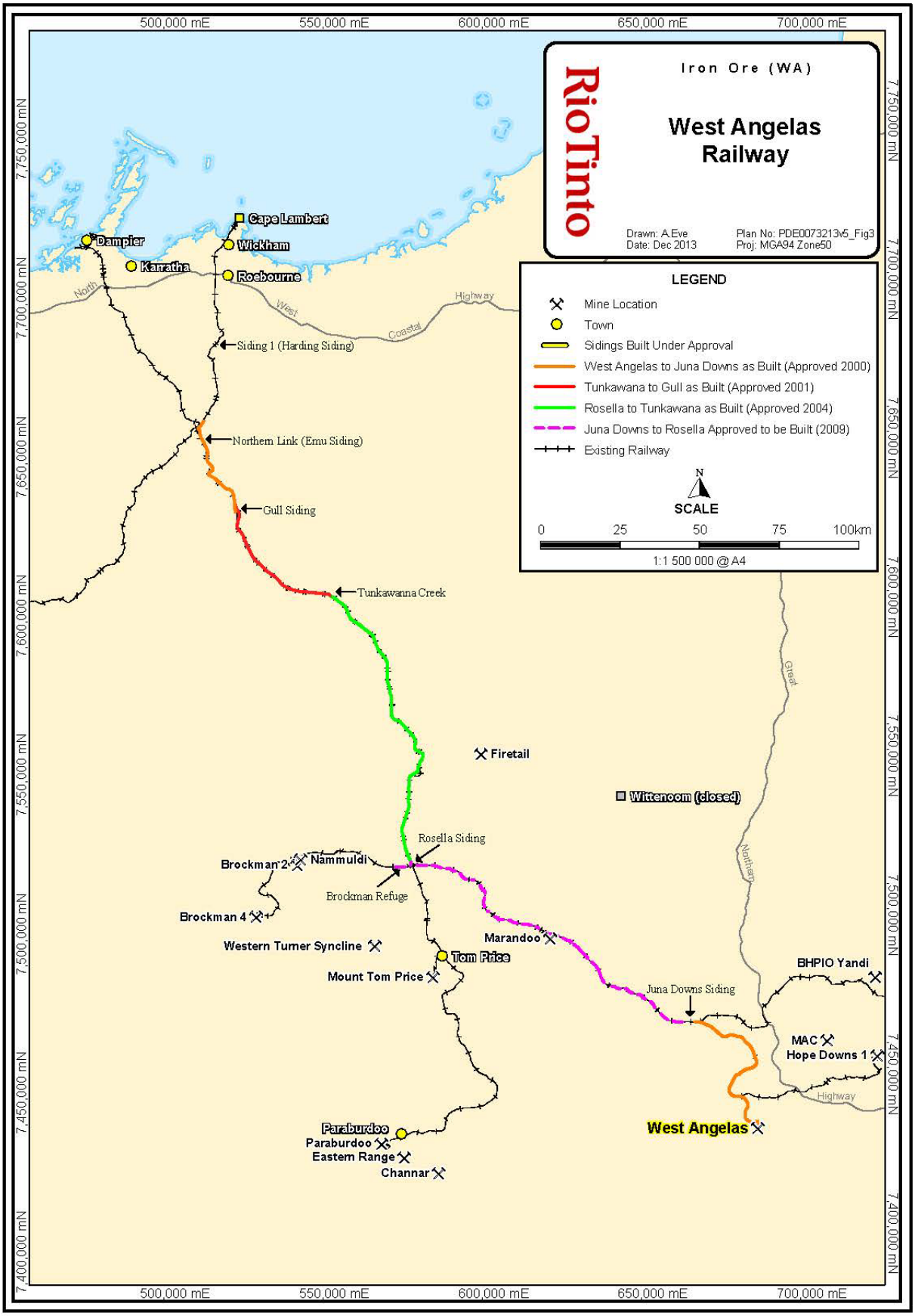


**Figure 8 West Angelas Railway**

Rio Tinto Iron Ore group

# West Angelas Closure Plan

July 2014

FDMS No. RTIO-HSE-0228290

Mineral Field 47 – West Pilbara

Contact details:

Kirsty Beckett
Rio Tinto
Central Park
152-158 St Georges Terrace
Perth 6000

# Corporate closure planning statement

Rio Tinto's iron ore group (Rio Tinto) considers closure planning to be an integral part of its business. The process of preparing for closure begins in the early stages of project development, and continues throughout the life of the mine.

A team of in-house rehabilitation and closure planning specialists has been established within the Rio Tinto iron ore business to manage this aspect of our operations. A Rehabilitation and Closure Working Group has been established to facilitate integration of closure planning into the broader mine planning framework, and to oversee the research and improvement projects recommended in each closure plan. In this way, Rio Tinto aims to continually improve both its understanding of closure risks, and the strategies employed to mitigate them.

This plan documents the current closure knowledge base for West Angelas. It outlines the objectives that need to be met at closure, the strategies and plans to be employed to achieve them, and provides an indication of the criteria that will be used to assess closure success.

However; this is not a static document. Rio Tinto will continue to revisit its closure plans on a regular basis to ensure that the objectives to which it is working towards remain relevant and aligned to stakeholder expectations, and to revise its strategies and plans where appropriate to achieve improved closure outcomes.

I hereby certify that to the best of my knowledge, the information within this closure plan is true and correct and addresses the relevant requirements of the *Guidelines for Preparing Mine Closure Plans* approved by the Director General of Mines.



David Bloor
General Manager - Health, Safety and Environment

# Executive summary

**Overview**
West Angelas is an open cut iron ore mine located in the Eastern Pilbara region of Western Australia, approximately 105 km north-west of Newman. The mine uses conventional drill-and-blast and load-and-haul mining methods to remove iron ore from above and below the water table.

**Scope**
This closure plan is designed to address the closure requirements for Rio Tinto Iron Ore's West Angelas deposits, as well as associated mine site infrastructure. Closure is assumed to include progressive rehabilitation that will occur throughout the life of the mine. The goal of mine closure at West Angelas is to relinquish the site to the Government.

The closure plan has been developed to meet the requirements of the Rio Tinto Closure Standard and the joint Office of the Environmental Protection Authority / Department of Mines and Petroleum Guidelines for Preparing Mine Closure Plans (2011).

**Primary obligations and commitments**
West Angelas is subject to the *Iron Ore (Robe River) Agreement Act 1964* and Ministerial Statement 970 approved under Part IV of the *Environmental Protection Act 1986*.

**Post-mining land use**
Options for post-mining land use are limited, with mining and pastoralism the only industries that have historically proven viable. Land use options under consideration include a change to pastoralism or return to a native ecosystem.

**Closure objectives and completion criteria**
The following closure objectives have been agreed for West Angelas:
- Minimise the long term visual impact by reshaping the land so it is compatible with the adjacent landscapes;
- Re-establish self-sustaining ecosystems;
- Ensure no changes to groundwater quality through evaporation; and
- Address public safety hazards.

Note that these objectives do not represent the full range of closure issues that may be present at the site. Rather the objectives reflect key issues against which closure performance will be assessed by government regulators.

Indicative completion criteria have been proposed within the closure plan, however further work is required to clarify and quantify the completion criteria.

**Anticipated closure outcome**
The shape of the landscape at West Angelas is still evolving, with the final mine void areas and waste dump locations and dimensions still in development across all of the deposits.

On closure of the mine all infrastructure will be removed. The mine voids are expected to be backfilled to prevent the formation of permanent pit lakes; although water may temporarily pool at the base of the voids following heavy rainfall. The area around the mine voids will be unstable, as the pit walls are expected to collapse over time. However, caves containing important environmental and cultural features will remain outside of this zone of instability, and be left undisturbed.

Waste dumps will remain external to the voids. The waste dumps and other disturbance areas across the site will be shaped to create stable landforms and vegetated with native species of local provenance. It is not intended that creeks diverted during the operational life of the mine be restored as part of the closure strategy, as new drainage networks may be established over the disturbance areas in consideration of the new topography created following decommissioning activities.

# DMP/OEPA Guidelines checklist

| Q | Plan Checklist | Y/N | Page | Comments |
|---|---|---|---|---|
| 1 | Has the checklist been endorsed by a senior representative within the operating company? | Y | 2 | |
| 2-5 | Questions relevant to DMP administration of closure plans | n/a | - | |
| 6 | Does the project summary include land ownership details, location of the project, comprehensive site plans and background information on the history and status of the project? | Y | 15 | |
| 7 | Has a consolidated summary or register of closure obligations and commitments been included? | Y | 18 | Also see Appendix A |
| 8 | Has information relevant to mine closure been collected for each domain or feature? | Y | 74 | |
| 9 | Has a gap analysis been conducted to determine if further information is required in relation to closure of each domain or feature? | Y | 67 | |
| 10 | Have all stakeholders involved in closure been identified? | Y | 58 | |
| 11 | Has a summary or register of stakeholder consultation been provided, with details as to who has been consulted and the outcomes? | Y | 59 | |
| 12 a | Does the plan include agreed post-mining land use? | N | 62 | Options still under discussion |
| 12 b | Does the plan include closure objectives? | Y | 62 | |
| 12 c | Does the plan include a conceptual landform design diagram? | Y | 64 | |
| 13 | Does the plan identify all potential (or pre-existing) environmental legacies which may restrict the post mining land use (including contaminated sites)? | Y | 28 | |
| 14 | Does the plan identify all (known) key issues impacting mine closure objectives and outcomes? | Y | 25 | |
| 15 | Does the plan include proposed management or mitigation options to deal with these issues? | Y | 50 | |
| 16 | Have the process, methodology and rationale been provided to justify identification and management of the issues? | Y | 50 | |

| Q | Plan Checklist | Y/N | Page | Comments |
|---|---|---|---|---|
| 17 | Does the plan include an appropriate set of specific completion criteria and/or closure performance indicators? | Y | 71 | |
| 18 | Does the plan include costing methodology, assumptions and financial provision to resource closure implementation and monitoring? | Y | 73 | |
| 19 | Does the plan include a process for regular review of the financial provision? | Y | 73 | |
| 20 | Does the plan include a summary of closure implementation strategies and activities for the proposed operations or for the whole site? | Y | 74 | |
| 21 | Does the plan include a closure work program for each domain or feature? | P | 74 | Programs for domains will be developed as part of the decommissioning plan |
| 22 | Have site layout plans been provided to clearly show each type of disturbance? | Y | 74 | |
| 23 | Does the plan contain a schedule of research and trial activities? | Y | 70 | |
| 24 | Does the plan contain a schedule of progressive rehabilitation activities? | Y | 74 | |
| 25 | Does the plan include details of how unexpected closure and care and maintenance will be handled? | Y | 78 | |
| 26 | Does the plan contain a schedule of decommissioning activities? | N | - | Will be developed as the site approaches closure. Decommissioning strategies are included in this closure plan. |
| 27 | Does the plan contain a schedule of closure performance monitoring and maintenance activities? | Y | 79 | |
| 28 | Does the plan contain a framework, including methodology, quality control and remedial strategy for closure performance monitoring including post-closure monitoring and maintenance? | P | 79 | An indicative monitoring program has been provided, with more detail introduced as the site approaches closure. |
| 29 | Does the mine closure plan contain a description of management strategies including systems and processes for the retention of mine records? | Y | 81 | |

# Table of common acronyms

| Acronym | Description |
|---|---|
| AHD | Australian Height Datum |
| AMD | Acid and / or Metalliferous Drainage |
| ASL | Above Sea Level |
| BIF | Banded Iron Formation |
| BOM | Bureau of Meteorology |
| BWT | Below Water Table |
| CALM | Department of Conservation and Land Management (now DPAW) |
| CSIRO | Commonwealth Scientific and Industrial Research Organisation |
| CSMP | Contaminated Sites Management Plan |
| DEC | Department of Environment and Conservation (now DER and DPAW) |
| DER | Department of Environmental Regulation |
| DMP | Department of Mines and Petroleum |
| DPaW | Department of Parks and Wildlife |
| DSD | Department of State Development |
| EMP | Environmental Management Program |
| ENSO | El Nino Southern Oscillation |
| EP Act | *Environmental Protection Act 1986* |
| EPA | Environmental Protection Authority |
| FIFO | Fly In Fly Out |
| FMMP | Fibrous Minerals Management Plant |
| GAI | Geochemical Abundance Index |
| GIS | Graphical Information System |
| IOD | Indian Ocean Dipole |
| IODMS | Iron Ore Document Management System |
| IORR | Iron Ore (Robe River) |
| ISO | International Standards Organisation |
| LAORS | Legal And Other Requirements |
| MS | Ministerial Statement |
| OEPA | Office of the Environmental Protection Authority |
| PAF | Potential Acid Forming |
| PCO | Present Cost Obligation |
| SCARD | Spontaneous Combustion and Acid Rock Drainage |
| TPC | Total Projected Cost of closure |

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# Introduction to closure planning

## 1. What is a closure plan?

A closure plan documents strategies to achieve the desired post-closure landform and avoid or mitigate potential social and environmental impacts associated with site closure, to an extent that is fiscally appropriate. As such, closure plans provide the framework for planning and implementing closure of Rio Tinto iron ore mine sites. Closure plans also document tasks the company has committed to undertake to improve closure outcomes.

Closure plans are intended to be used by site personnel to inform on-going planning decisions, and to ensure closure is integrated into operational activities. Closure plans are also one of the methods used by the business to communicate its closure strategy to stakeholders, including regulators.

Closure plans are regularly updated to account for changes resulting from:

- amendments to the mine plan;
- improvements of the site closure knowledge base (e.g. through daily activities, technical studies and research actions);
- new or amended regulation;
- changes to surrounding land uses; and
- evolving stakeholder expectations.

A key output of closure planning is the development of a closure cost estimate. Closure provisions are subsequently integrated into our business planning processes to ensure funds will be available to close the site effectively.

The detail of each closure plan increases as the knowledge base develops. When the site moves to within five years of scheduled closure, a Decommissioning Plan is prepared. The Decommissioning Plan is the final closure plan produced for a site.

Decommissioning plans are used to direct the physical closure, dismantling and subsequent rehabilitation of the site (excluding progressive rehabilitation undertaken during operations), and include location specific management plans for each closure aspect in each closure domain identified. The Decommissioning Plan builds upon strategies developed in earlier closure plans and details how they are to be implemented.

A decommissioning study is undertaken at this time, to support development of the Decommissioning Plan. Stakeholder engagement and endorsement of final completion criteria is facilitated at this time. This study also investigates how infrastructure, decontamination, rehabilitation, the workforce and communications will be managed throughout the mine closure period (and beyond), specific to the site conditions at the end of mining.

## 2. The closure planning process

Rio Tinto integrates closure planning into the mine planning process. As a result, closure planning is not a stand-alone process. Activities within the business that specifically address closure and its potential impacts include:

- life of mine and shorter term mine plans;
- expansion studies;
- mine and waste dump design reviews;
- progressive rehabilitation;
- internal technical studies and Rio Tinto supported research activities; and
- the Rio Tinto Iron Ore group Closure and Rehabilitation Working Group.

Closure plans are reviewed on a regular basis in accordance with both internal and external planning obligations. The review process brings technical and site experts together to discuss current performance, changes including knowledge base improvements, stakeholder feedback on the current plan, future options and remaining knowledge gaps. At the end of the review improvement actions are assigned and

integrated into work plans, and the closure plan is updated to record the review outcomes.

# Purpose and scope

## 3. Purpose

Planning for closure of a site is a critical business process that demonstrates Rio Tinto's commitment to sustainable development. The report follows the format and content requirements for mine closure plans as recommended by the Western Australian Government *Guidelines for Preparing Mine Closure Plans*[1], and is designed to comply with Rio Tinto's internal management expectations for mine closure as defined in the Rio Tinto Closure Standard[2].

This closure plan has been produced to:

- comply with Ministerial Statement 970 condition 9 for rehabilitation and closure;
- update the West Angelas closure plan to include the expansion areas of Deposit A West and Deposit F; and
- meet Rio Tinto internal compliance requirements to review and update the closure plan every six years.

## 4. Scope

This plan covers the closure, rehabilitation and decommissioning of facilities and disturbed areas associated with mining activities at West Angelas, including:

- open cut pits at deposits A, B, E, F and A West, mineral waste dumps, haul roads and associated ground disturbance;
- wet processing plant, administration buildings, associated facilities and infrastructure, sealed and unsealed roads;
- Turee Creek B borefield, dewatering borefield, pipelines, discharge outlets and associated infrastructure;
- accommodation camp;
- rail loop and spur; and
- airstrip.

The scope of this closure plan currently excludes:

- future expansions at the site. These deposits will be addressed in future updates to this plan when mine planning is sufficiently developed; and
- the mainline rail, which is captured in a stand-alone Rail Closure Statement.

## 5. Closure plan review history

A decommissioning and rehabilitation management plan for West Angelas was submitted to regulators in December 1999 and updated in November 2004 to fulfil the requirements of Ministerial Statement (MS) 514 condition 13, as part of the West Angelas Environmental Management Programme (EMP).

In 2008, a dedicated closure plan was developed for internal use only, in accordance with the Rio Tinto Closure Standard, addressing the closure requirements for deposits A and E only. (Deposit B had yet to be developed and was not considered in this closure plan.)

MS 970 was published on 12 June 2014; replacing and superseding all previous conditions of MS 514. Of importance to this closure plan, management of rehabilitation and closure was separated from the Environmental Management Programme, to form a separate Mine Closure Plan (MS 970 Condition 9, discussed further in Section 7.2 *Ministerial Statements*), and commitments specific to drainage diversion management were altered to create a holistic approach to surface water management (MS 970 condition 7).

[1] Department of Mines & Petroleum and Office of the Environmental Protection Authority (2011) Guidelines for Preparing Mine Closure Plans, June 2011, http://www.dmp.wa.gov.au/documents/Mine_Closure(2).pdf.

[2] Rio Tinto (2013) Closure Standard, March 2013, http://www.riotinto.com/documents/Library/Closure_Standard_EN.pdf

This closure plan is the first plan to be developed under MS 970. This mine closure plan has been developed using information current as at July 2014. The plan has been prepared for external review and supersedes all previous closure, decommissioning and rehabilitation plans.

# Site overview

## 6. Description of operation

### 6.1 Overview

West Angelas is located in the Eastern Pilbara region of Western Australia, approximately 105 km north-west of Newman (as depicted in Figure 1). The location is very remote, with no neighbouring mining or pastoral activities, the dominant economic industries undertaken in the Pilbara. West Angelas is acknowledged to support diverse flora and fauna for its size due to the variety of relief and geological types which combine to provide a great diversity of habitats.

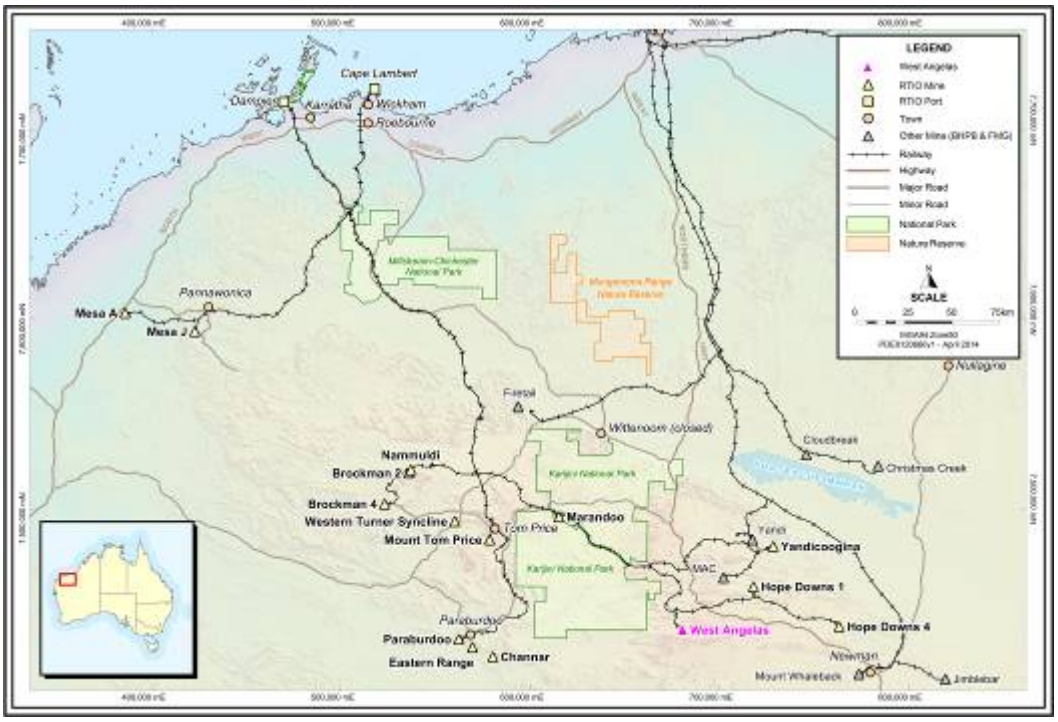


**Figure 1: General location of West Angelas mine**

West Angelas is operated by Rio Tinto iron ore, on behalf of the Robe River Mining joint venture (JV) of whom Rio Tinto is the largest stakeholder. The Robe River Mining JV comprises:

- Rio Tinto (53%);
- Mitsui Iron Ore Development Pty Ltd (32%)
- Pannawonica Iron Associates (10%); and
- Cape Lambert Iron Associates (5%).

### 6.2 Mining layout

West Angelas utilises standard truck and shovel methods to develop open pit iron ore deposits. The current mine layout is shown in Figure 2, which also highlights the location of deposits encompassed by this plan (Deposit A, A West, B, E and F). Note that Deposits A and B are divided into 'sub-deposits' for operational purposes (CEPN/CEPS and B1-3 respectively). This terminology is used in subsequent sections of the closure plan.

The operation includes:

- open cut pits that mine to depths below the natural groundwater table;
- mineral waste that is initially directed to surface waste dumps and, where practical, used in progressive backfilling of the mine pit;
- a network of dewatering borefield, pipelines, discharge outlets and associated infrastructure to facilitate access to below water table (BWT) resources;
- wet processing plant, associated infrastructure and facilities; and

- administration buildings, associated facilities, sealed and unsealed roads.

The Turee Creek B borefield is used to provide potable water to the mining operation and camp facilities and, when required, water to the processing plant. The borefield is located approximately 30 km west of the West Angelas minesite.

Note, a full site inventory is included in closure cost estimate reports for the site and is not reproduced in this report.

## 6.3 Mining schedule

Ore was first shipped from Deposit A in 2001. Mining at Deposit E commenced in 2011 and Deposit B is scheduled to commence in 2015. Major proposed milestones in the development, operation and closure of the respective deposits are presented in Table 1, however it should be noted that mine plans undergo constant review and modification, and consequently this information should only be used as an indication of future mining and development.

**Table 1: Indicative mining schedule**

| Deposit | Indicative commencement | Indicative completion |
|---|---|---|
| Deposit A | Commenced | 2019 |
| Deposit A West | 2023 | 2029 |
| Deposit B | 2014 | 2029 |
| Deposit E | Commenced | 2023 |
| Deposit F | 2016 | 2029 |

## 6.4 Post-mining and post-closure landforms

This closure plan differentiates between the post-mining landform and the post-closure landform.

- The post-mining landform refers to the landform that would be generated as a result of implementation of the current operational mine plan and standard operating practice. Issues that could potentially arise from this scenario, and strategies to manage them, are outlined in later sections of this closure plan.
- The post-closure landform is the final landform configuration that is proposed to remain after the implementation of rehabilitation earthworks during closure. The post-closure landform is described in Section 23.

Based on the current plan, the post mining landform will consist of nine separate mine voids which have been partially backfilled during operations to varying levels. The voids may require further backfill post operations to above the recovered groundwater table level(s).

Several mineral waste dumps will be present external to the mine voids, as well as one in pit waste dump at the western end of Deposit A that will extend above the pit crest.

It is assumed that all of the existing infrastructure and disturbance areas will be present at closure and will require decommissioning and subsequent rehabilitation.

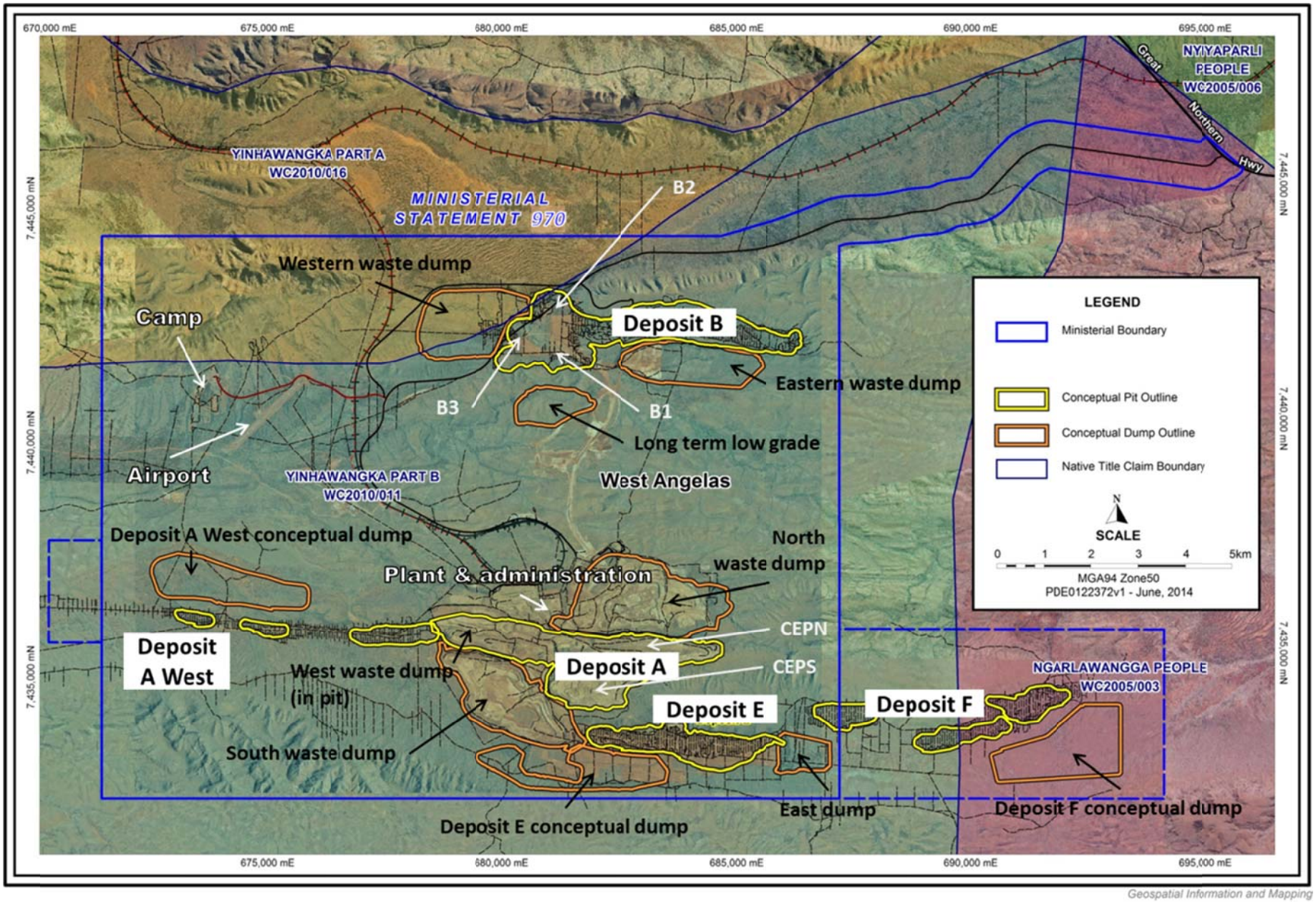


**Figure 2: West Angelas deposits and supporting infrastructure. Existing Part IV environmental approval and Native Title boundaries are also illustrated. Subdivisions of the deposits subject to different backfill requirements are presented in grey.**

# Closure obligations and commitments

Closure obligations arise from a range of sources, from legislative requirements to actions agreed with individual stakeholders.

## 7. Important elements of the general legislative framework

### 7.1 State Agreement legislation

A State Agreement is an Act of the Western Australian Parliament to govern major resources activities that are of economic or strategic importance to the State. All of Rio Tinto's Western Australian iron ore mines are subject to State Agreement[3]. The Department of State Development (DSD) is the responsible agency.

A key consequence of State Agreements is that they override the *Mining Act 1978* requirement to submit mining proposals, and therefore closure plans, to the Department of Mines and Petroleum (DMP).

State Agreements are structured so that laws protecting the environment, in particular requirements under the *Environmental Protection Act 1986* (EP Act), will still apply. Sites subject to State Agreements are therefore subject to environmental impact assessment by the Environmental Protection Authority (EPA) in addition to licensing by the Department of Environment Regulation (DER).

The *Iron Ore (Robe River) Agreement Act 1964* (ML248SA) was enacted to reflect an agreement between the State of Western Australia and Robe River Iron Associates (now part of the Rio Tinto group) in relation to mining on relevant Crown Land. The agreement is one of a number that provide an over-arching framework for regulating sites of economic significance to the State.

### 7.2 Ministerial Statements

Ministerial Statements (MS) are the end result of the environmental impact assessment process for approved projects, as outlined in Part IV of the EP Act.

Part IV of the EP Act outlines the process whereby approval is given to projects which have the potential for significant impact on the environment. Approval is granted by the Minister for the Environment under advice from the EPA. The approval process is public, with opportunities for the public to make submissions in respect to the project and rights to appeal against the content and recommendations in the EPA's report to the Minister.

The EPA expects closure plans to be submitted with the approvals documentation to facilitate the incorporation of closure issues into its environmental impact assessment.

Environmental management commitments for West Angelas Deposits A, B and E relevant to closure were initially established under MS 514. These commitments were enacted through MS 514 conditions 4 and 13 requiring an Environmental Management Plan (EMP) to be prepared and implemented prior to ground-disturbance activities (condition 4), which included a decommissioning and rehabilitation management plan (condition 13). The EMP, approved by regulators in December 1999, addressed Robe River Mining's commitment to ensure no changes to groundwater quality through evaporation in below water table pits by proposing to backfill pits to a level that would prevent capillary rise in the soil cover.

MS 970 was issued for the West Angelas Iron Ore Project in June 2014, replacing and superseding all previous conditions of MS 514. MS 514 closure management

[3] Note that whilst all Rio Tinto iron ore mine sites are covered by State Agreements, some ancillary areas (e.g. camps, infrastructure services, etc.) may be located outside the Agreement boundary.

requirements were replaced by MS 970 condition 9 Rehabilitation and closure which states:

*9-1 The proponent shall ensure that the mine is closed, decommissioned and rehabilitated in an ecologically sustainable manner, consistent with agreed post-mining outcomes and land uses, and without unacceptable liability to the State of Western Australia.*

*9-2 The proponent shall prepare a Mine Closure Plan for the West Angelas Iron Ore Project.*

*9-3 The Mine Closure Plan required by condition 9-2 shall:*
*(1) when implemented, manage the implementation of the proposal to meet the requirements of condition 9-1;*
*(2) be prepared in accordance with the Guidelines for Preparing Mine Closure Plans, June 2011 (Department of Mines and Petroleum and Environmental Protection Authority) or its revisions; and*
*(3) be to the requirements of the CEO on advice of the Department of Mines and Petroleum.*

*9-4 Within 12 months of commissioning of additional mine pits or as otherwise agreed by the CEO the proponent shall implement the approved Mine Closure Plan and continue implementation until otherwise agreed by the CEO.*

*9-5 Revisions to the Mine Closure Plan may be approved by the CEO on the advice of the Department of Mines and Petroleum.*

*9-6 The proponent shall implement revisions of the Mine Closure Plan required by condition 9-5.*

## 7.3 Mining Act

Mining proposals are required to be submitted and approved under the *Mining Act 1978*. This is the primary legislation under which mine closure is regulated in Western Australia and the DMP is the responsible agency.

In accordance with amendments to the *Mining Act 1978* made in 2010, all new mining proposals are required to contain a mine closure plan prepared in accordance with the joint DMP/EPA Guidelines for Preparing Mine Closure Plans (2011).

The *Mining Act 1978* requirements also apply to operational areas that are not covered under State Agreement legislation. Some mining areas (e.g. waste dumps, fines dams) and ancillary infrastructure (e.g. mining camps) may fall into this category. However, the DMP has indicated that it does not necessarily expect formal closure plans to be submitted with such proposals.

The *Mining Act 1978* requires mining companies to review and lodge updated closure plans at least every three years (unless otherwise authorised). Rio Tinto iron ore mines in the Pilbara are subject to State Agreements, which are administered by the DSD. The DSD does not require closure plans to be submitted. As this site is subject to State Agreement legislation, the requirement to submit a closure plan under the *Mining Act 1978* does not apply.

Tenure held under the Mining Act at West Angelas and relevant to this closure plan includes:

- General purpose leases 47/1235 and 47/1236;
- Miscellaneous LicencesL47/409 issued for the West Angelas gas pipeline and power station; and
- other Miscellaneous Licences 47/52, 47/53, 47/54, 47/60, 47/61, 47/62 issued for the purposes of roads and power lines, the repeater station and road, pipeline and power lines.

Tenure boundaries are presented relative to the EPA Part IV MS 970 boundary in Figure 3.

## 7.4 Native vegetation clearing permits

Mining activities undertaken outside of the Part IV process of the EP Act are subject to Native Vegetation Clearing Permits (NVCP) under Part V of the EP Act. An area permit is required before clearing specific areas of native vegetation, or alternatively a purpose permit is required for programs of clearing, such as ongoing maintenance projects.

Some mining and petroleum activities are exempt from requiring a clearing permit. These activities involve clearing for 'exploration' (excluding environmentally sensitive areas) or 'low impact or other mineral or petroleum activities' (excluding non-permitted areas). Examples of low impact activities include temporary tracks, groundwater drilling and clearing less than two hectares for camp sites.

NVCPs that have been obtained to support operation and development of the West Angelas mine are listed in Table 2. It is noted that the rehabilitation requirements associated with these permits may be completed prior to or following expiration of these permits, but are expected to occur prior to mine closure.

**Table 2: Native Vegetation Clearing Permits at West Angelas.**

| Clearing permit | Seed provenance area (km) | Time to commence rehabilitation |
|---|---|---|
| 3047/3 | Not specified | Not specified |
| 3320/1 | Not specified | Not specified |
| 3758/1 | 50 | Within 12 months |
| 3893/2 | 200 | Within 12 months |
| 3893/3 | Not specified | Not specified |
| 4070/1 | 50 | Within 12 months |
| 4394/1 | 100 | Within 12 months |
| 4830/1 | 100 | Within 12 months |
| 4830/2 | Not specified | Not specified |
| 4722/1 | 100 | Within 12 months |
| 5185/3 | Not specified | Not specified |
| 4466/2 | Not specified | Not specified |
| 5246/1 | 100 | Within 12 months |
| 5996/1 | Not specified | Not specified |
| 6016/1 | Not specified | Not specified |

## 7.5 Native title

The Yinhawangka (Gobawarrah Minduarra Yinhawanga) People are the native title claimants and traditional custodians of the majority of the land identified in this closure plan footprint. The Ngarlawangga People are the native title claimants for a portion of the Deposit F area. Rio Tinto reached a Claim Wide Participation Agreement with the Yinhawangka People in 2013 and the Ngarlawangga People in 2011. Figure 2 shows the native boundaries across the site.

The Participation Agreement commits Rio Tinto to work together with Yinhawangka and Ngarlawangga on country to manage and maintain the areas in which Rio Tinto operates. These comprehensive agreements set clear guidelines for processes such as land access, tenure, heritage and environmental approvals, mining benefits payments and reporting and communication requirements. As part of the Agreement, Rio Tinto has committed to consult with Yinhawangka and Ngarlawangga in relation to life of mine planning. This includes consultation with regards to closure.

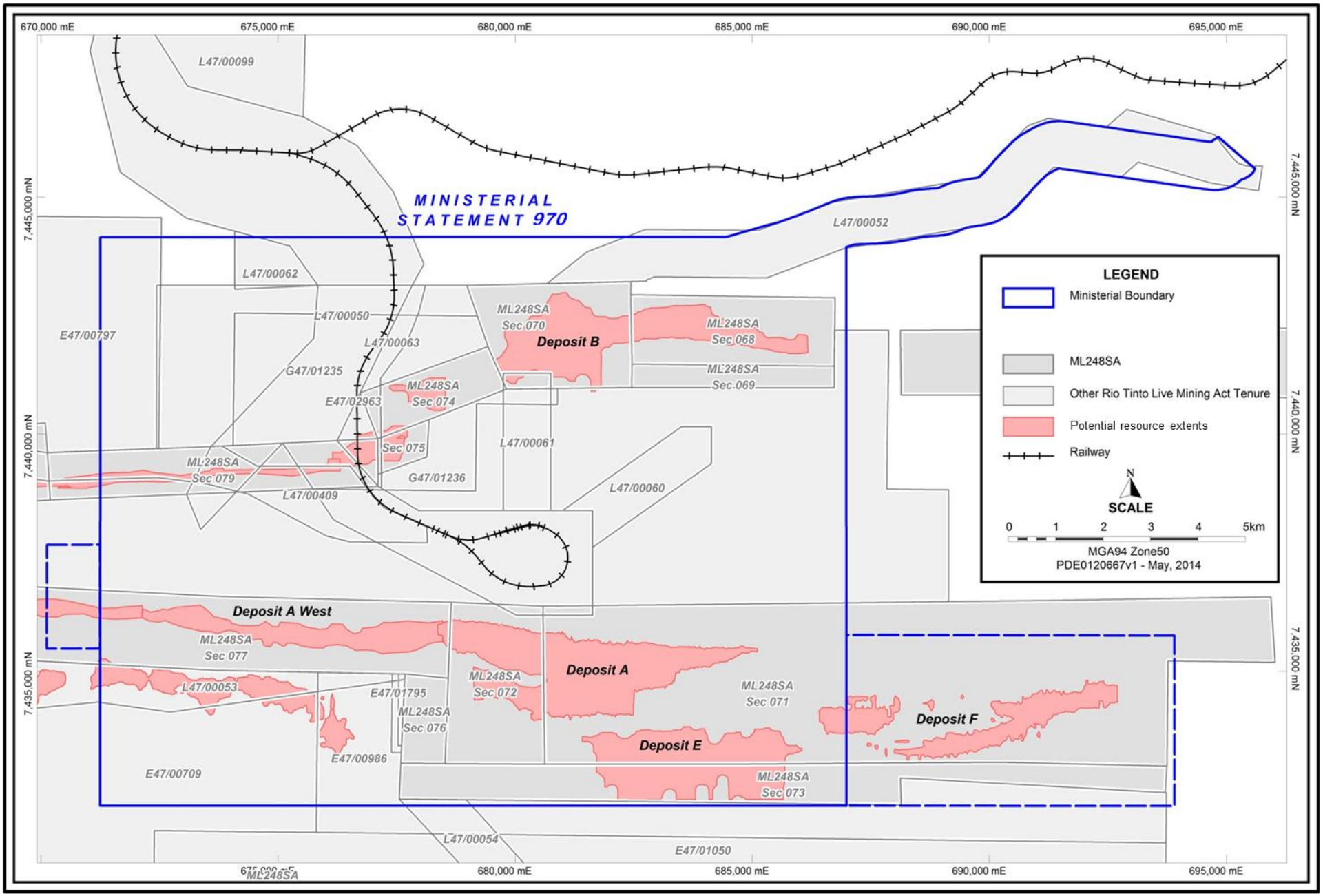


**Figure 3: Tenure boundaries relative to potential resource extents at West Angelas.**

### 7.6 Other statutory obligations relevant to closure

Additional statutes and regulations create obligations and/or considerations that may be of relevance to the rehabilitation and closure of the site, to the extent that they are not inconsistent with the provisions of the State Agreement. These include, but are not limited to:

- *Contaminated Sites Act 2003* (WA), and Guidelines gazetted under this Act;
- Environmental Protection (Controlled Waste) Regulation 2004 (WA);
- Environmental Protection (Unauthorised Discharges) Regulations 2004 (WA);
- Environmental Protection (Rural Landfill) Regulations 2002 (WA);
- *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth);
- *Rights in Water and Irrigation Act 1914* (WA);
- *Wildlife Conservation Act 1950* (WA);
- *Aboriginal Heritage Act 1972* (WA);
- *Mine Safety and Inspection Act 1994* (WA);
- Health (Asbestos) Regulations 1992 (WA);
- *Land Drainage Act 1925* (WA);
- *Dangerous Goods Safety Act 2004* (WA), and associated regulations;
- *Conservation and Land Management Act 1984* (WA); and
- *Land Administration Act 1997* (WA).

Although many of the above are not discussed further in this document, Rio Tinto iron ore has considered the relevance of each in the development of the closure plan and has taken appropriate action where required.

## 8. Regulatory and industry guidelines

### 8.1 Guidelines for preparing mine closure plans

The DMP and EPA have issued the Guidelines for Preparing Mine Closure Plans (the Guidelines) to establish standards for closure plans being submitted to State Government. The Guidelines have legislative force because the Mining Act 1978 has been amended to specifically state that mining proposals must include a closure plan, and closure plans are defined to be a document that:

- is in the form required by the guidelines; and
- contains information of the kind required by the guidelines.

Regulations routinely recommend the imposition of conditions on Ministerial Statements requiring plans that are compliant with the Guidelines to be prepared, even on mines subject to State Agreement.

Rio Tinto recognises that the Guidelines provide a suitable format for development of mine closure plans, and this closure plan has been prepared to comply with the key elements and structure of the guidelines.

### 8.2 Other guidelines

In addition to the guidelines, the DMP has developed a number of guidelines and environmental notes in relation to mining and rehabilitation, which include:

- Environmental Notes on Mining – Waste Rock Dumps[4];
- Mine Void Water Resource Issues in Western Australia[5]; and
- Mining Environmental Management Guidelines, Safe Design and Operating Standards for Tailings Storage[6].

Other key government and industry guidelines relevant to mine closure and rehabilitation include:

[4] Department of Mines and Petroleum 2009, *Environmental Notes on Mining – Waste Rock Dumps*.

[5] Johnson SL and AH Wright 2003, *Mine Void Water Resources Issues in Western Australia*, [Former] Water and Rivers Commission, Perth.

[6] [Former] Department of Minerals and Energy 1999, *Mining Environmental Management Guidelines, Safe Design and Operating Standards for Tailings Storage*.

- Strategic Framework for Mine Closure[7];
- Enduring Value – The Australian Minerals Industry Framework for Sustainable Development[8];
- Mine Closure and Completion[9];
- Mine Rehabilitation[10]; and
- Landform Design for Rehabilitation[11].

# 9. Closure obligations summary

Table 3 provides a summary of key actions related to site-specific closure obligations and associated information. These closure obligations arise from mining tenement conditions, commitments in mining proposals, conditions of environmental approvals and other agreed actions. A detailed register is presented in Appendix A of this closure plan.

Some of the information and obligations identified may not be legally binding, however the purpose of the summary is to identify all existing obligations as well as information and options that have been raised relating to closure. This information has been considered in defining closure objectives, strategies and indicative completion criteria employed in this closure plan.

The inclusion of a particular obligation is not a representation as to its legal effect nor is intended to give rise to any separate legally binding commitment.

[7] Australian and New Zealand Minerals and Energy Council and Minerals Council of Australia (ANZMEC/MCA) 2000, *Strategic Framework for Mine Closure*, National Library of Australia Catalogue Data.

[8] Minerals Council of Australia 2004, Enduring Value – *The Australian Minerals Industry Framework for Sustainable Development*.

[9] Department of Industry, Tourism and Resources (DITR) 2006, *Mine Closure and Completion*.

[10] Department of Industry, Tourism and Resources (DITR) 2006, *Mine Rehabilitation.*

[11] Environment Australia 2002, *Landform Design for Rehabilitation. Best Practice Environmental Management in Mining,* Commonwealth of Australia.

**Table 3: Closure obligations summary**

| Aspect | Key sources of obligations | Intent of closure commitment |
|---|---|---|
| Decommissioning | Clause 10(e) of Iron Ore Robe River agreement Act 1964 | On the cessation or determination of any lease license or easement the improvements and things erected other than plant and equipment shall remain or become property of the State<br>The Company must notify the State immediately before deciding to remove its locomotives rolling stock plant or equipment, granting to the State the right or option to purchase the plant and / or equipment within three months. |
| | Mining Proposal 20934<br>Fibre optic cable | • Cable located 1m below ground level to be left in situ. |
| | Mining Proposal 33113<br>Power station | • Decommissioning and rehabilitation if no longer required for other projects or land users in the area<br>• If decommissioned, infrastructure to be removed, bituminised surfaces removed to an appropriate disposal site and the area rehabilitated. |
| | GPL 47/1235, GPL 47/1236 | • Buildings and structures removed from site or demolished and buried |
| | L47/409, L47/53, L47/54 | • Remove installations, cover wells and holes in the ground and rehabilitate |
| | L47/52 | • Holes drilled for the purpose of exploration are to be capped, filled or otherwise made safe<br>• Backfill and rehabilitate disturbances to the land surface no later than 6 months after excavation<br>• waste materials, equipment and temporary buildings to be removed |
| Rehabilitation | DEC Licence L7774/2000/6<br>Tyre storage and disposal | • Groups of not more than 1000 whole tyres or 40 cubic metres of tyre pieces are to be buried as soon as practicable after placement in the waste dumps.<br>• A minimum cover to tyre ratio of 4 to 1 with a minimum of 100mm of soil cover is to be maintained over the buried tyres following disposal and a final cover of not less than 2 metres of soil. |
| | GPL 47/1235<br>GPL 47/1236 | • Progressively where possible and at the completion of operations, disturbed areas rehabilitated and revegetated with local native grasses, shrubs and trees |
| | West Angelas Environmental Management Plan 2014 | • Progressive rehabilitation of cleared / disturbed areas where possible.<br>• Seeds from as many native plant species of local provenance as possible used for rehabilitation<br>• Mineral waste progressively backfill into mine pit voids to above the natural ground water level as far as practicable |
| | Native Vegetation Clearing Permits | • See Table 2 |
| Landform design | West Angelas Environmental Management Plan 2014 | • Mineral waste progressively backfill into mine pit voids to above the natural ground water level as far as practicable<br>• Mineral waste dump designs to consider shaping to blend in with the surrounding natural topography<br>• Mineral waste dumps located near drainage features to use rock armouring or other stabilising material if erosion occurs |
| Local community | | • No closure action specific obligations that relate to local communities or Traditional Owners have been identified. |

# Collection and analysis of closure data

This section forms part of the closure knowledge base, and is intended to summarise the anticipated post-mining landform conditions, present key baseline data and associated analyses, and identify knowledge gaps.

Information collated in this section reflects our current knowledge at the time of preparation of the plan. A summary of the technical reports that contribute to the closure knowledge base is provided in Appendix B.

The contents of the closure knowledge base will evolve over time. As a result, some components of some reports and studies are superseded by new research or studies or, as a consequence of changes in the mine plan, may constitute new gaps in our knowledge at the time of this closure plan update. For these reasons the technical reports are not appended to this closure plan. All technical reports relevant to the closure of the operation will be consolidated and presented as part of the Decommissioning Plan.

## 10. Climate

Climatic information, particularly rainfall, rainfall intensity, cyclone frequency and evaporation is relevant to many aspects of mine closure. In particular, it potentially has a significant effect on the geotechnical and vegetative stability of final landforms including waste dumps.

The general climate of the Pilbara can be described semi-arid, characterised by a hot summer (October to April) and a mild winter (May to September).

### 10.1 Weather stations

Rio Tinto iron ore has a monitoring station at the West Angelas operations, and has been recording data since July 2004. The Bureau of Meteorology (BOM) maintains a station at Newman Aerodrome (BOM station number: 007176). This station has been selected to provide long term climate data for closure planning as it is the closest BOM station to West Angelas, is located in a similar climate zone, and has been operational since 1971 thus providing 33 years of climate records.

Information provided in this section is based on information analysed from both the West Angelas (2005 to 2013) and Newman Aero (1971 to 2013) monitoring stations.

### 10.2 Rainfall and significant weather events

The north/north-western coastline of Australia has experienced more tropical cyclones than anywhere else on mainland Australia. Most tropical cyclones are observed during the late summer, occurring between November and May. Tropical cyclones can produce damaging wind gusts in excess of 150 km per hour, with heavy rains resulting in regional flooding. Five tropical cyclones are expected off the coast of the Pilbara each year, with two expected to make landfall.

Precipitation is driven by summer cyclonic activity, with the months of August, September and October have the lowest average rainfall, and December, January and February the highest average rainfall (Figure 4[12]). Annual rainfall is also highly variable, as evidenced by historical data from 1971 to 2013 (Figure 6).

[12] Bureau of Meteorology, Newman Aero dataset, Accessed: 20 March 2014

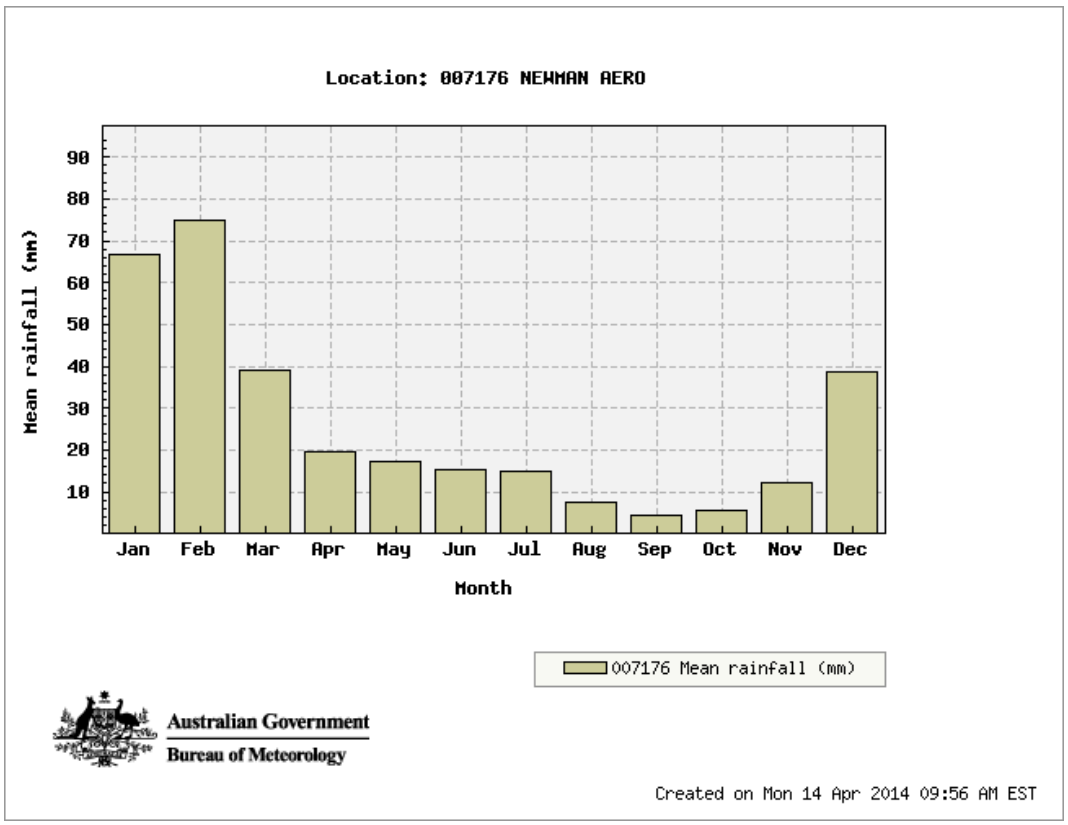


**Figure 4: Mean monthly rainfall (1971 to 2013) at Newman Aerodrome**

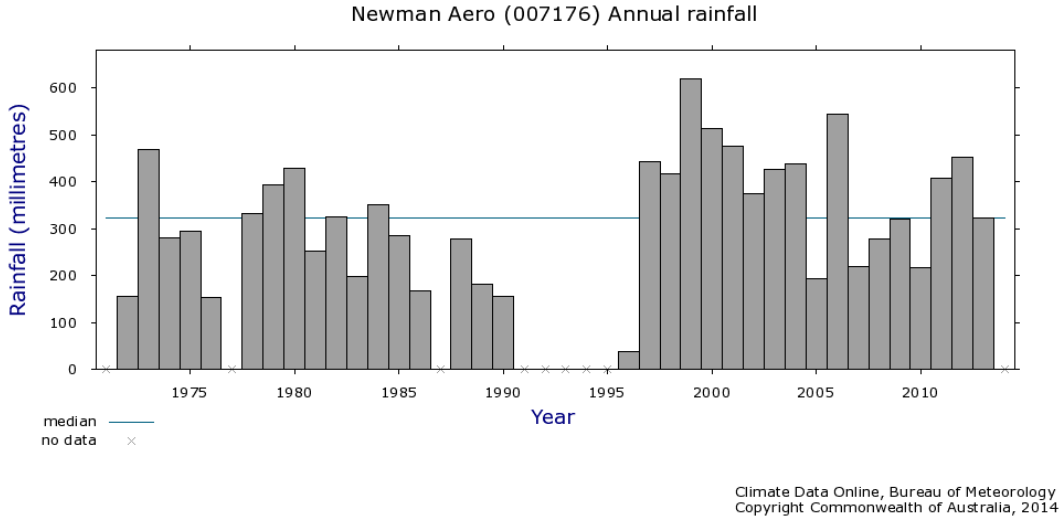


**Figure 5 Historical annual rainfall (1971 - 2013) at Newman Aerodrome**

## 10.3 Temperature

Temperatures at West Angelas range from an average maximum temperature of 44°C in January to an average minimum of 3°C in August[13].

Average temperatures at West Angelas during the day are typically between 36°C to 39°C over summer, and drop to 23°C to 26°C over winter. Average minimum temperatures are between 23°C to 24°C over summer, and 6°C to 7°C over winter. Monthly average temperatures recorded at Newman Aero between 1996 and 2013 are presented in Figure 6.

[13] Bureau of Meteorology, Newman Aerodrome dataset, Accessed: 20 March 2014

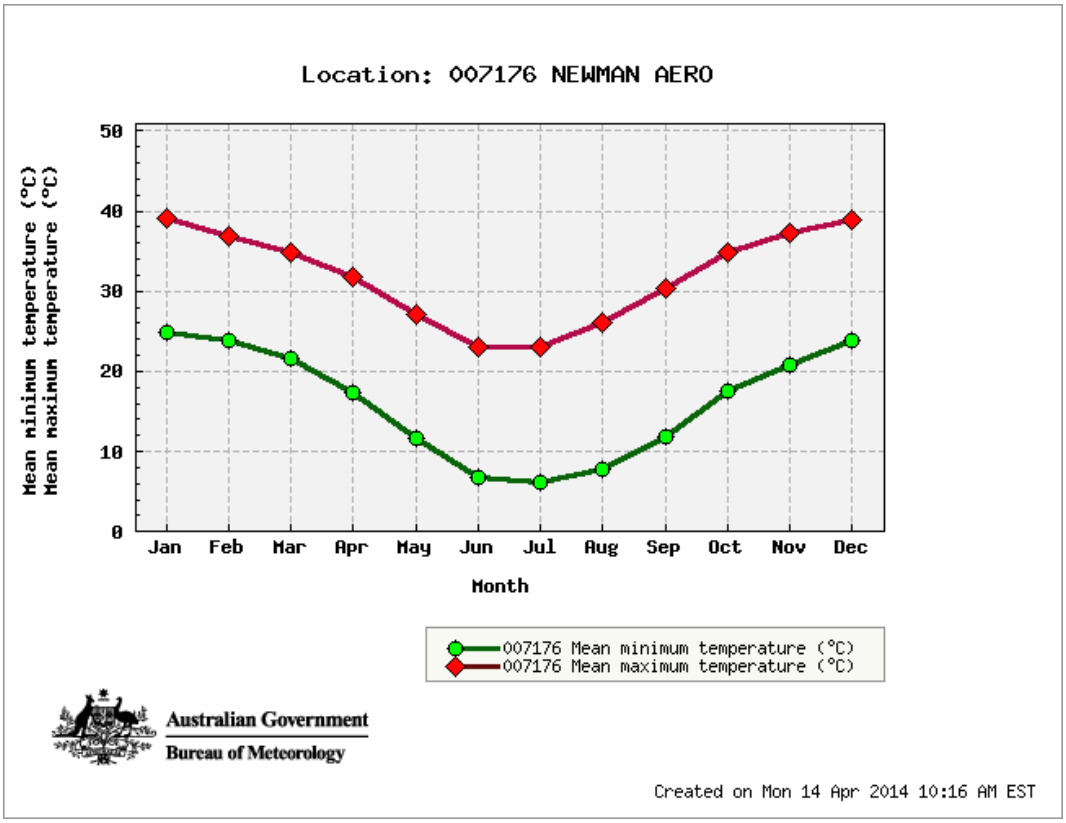


**Figure 6: Mean maximum and minimum monthly temperature data (1996 to 2013) at Newman Aerodrome**

## 10.4 Evaporation and humidity

Evaporation rates in the region greatly exceed rainfall. Evaporation at West Angelas is between 2500 to 3400 mm per annum while average humidity has been recorded as 37%, with higher humidity corresponding to higher annual rainfall.

## 10.5 Impact of climate change

The understanding of how climate will change in the future in the Pilbara is guided by the outcomes of climate modelling, commissioned privately by Rio Tinto iron ore and other Australian government agencies. The main climate drivers for the Pilbara are the El Niño Southern Oscillation (ENSO) and Indian Ocean Dipole (IOD) ocean currents. However, these ocean currents are not well represented in most global climate models, and as a result climate predictions for the northwest of Western Australia vary significantly. Consequently the impact of climate change, the change in water availability and influence on ecosystems, in the Pilbara is still unclear.

The ENSO and IOD ocean currents are currently being researched by CSIRO. At the same time, modelling is being progressively improved by various Australian Government agencies to expand our understanding of the climate drivers in the southern hemisphere, to understand the associated impacts on water availability and to predict changes to existing ecosystems.

From the modelling completed to date, our understanding of Pilbara climate change suggests the region will experience the following climate trends:

- A shift in the historical tropical cyclone season, with an earlier start and potentially later finish.
- Continuation of the highly variable multi-decadal scale rainfall trends.
- A significant warming trend, influencing maximum temperatures, with the largest changes during the January to March period.

Given the closure date for in-scope deposits (i.e. 2023), potential impacts associated with climate change in the context of closure have not been considered at this stage of the project development and are not discussed further in this document.

# 11. Land

## 11.1 Geographical overview

West Angelas is located in the southern part of the Pilbara Block, which contains some of the oldest rocks on record in Australia. Mining operations are located within two valleys which trend east-west and are separated by a low plateau of Jeerinah Formation. These valleys join together upstream of Karijini National Park. Hills and ridges are of low to moderate relief, and are fringed by larger hills of the east-west trending Brockman Iron Formation. High hills dominate the eastern end of the Turee Creek B borefield area.

Mount Meharry, the point of highest elevation in Western Australia (1251 m ASL) is located approximately 20 km north-west of West Angelas. Mount Robinson (1142 m ASL) is located to the north of Deposit H. The maximum height within the range formed by the Brockman Iron Formation is 1191 m ASL, while West Angela Hill to the north is 1010 m ASL. Pandtherunga Hill is the highest point within the West Angelas mining leases, at 969 m ASL. The surrounding plains average approximately 700 m ASL.

Seven land systems were identified as occurring in the West Angelas Operations, as listed in Table 4. Most of the operations occur within the Newman, Boolgeeda and Rocklea land systems.

**Table 4: West Angelas land systems and land units**

| Land System | Description |
|---|---|
| Newman | Rugged jaspilite plateaux, ridges and mountains supporting hard spinifex grasslands |
| Boolgeeda | Stony lower slopes and plains below hill systems supporting hard and soft spinifex grasslands and mulga shrublands |
| Rocklea | Basalt hills, plateaux, lower slopes and minor stony plains supporting hard spinifex (and occasionally soft spinifex) grasslands |
| Platform | Dissected slopes and raised plains supporting hard spinifex grasslands |
| Egerton | Dissected hardpan plains supporting mulga shrublands and hard spinifex hummock grasslands |
| Elimunna | Stony plains on basalts supporting sparse Acacia and cassia shrublands and patchy tussock grasslands. |
| Wannamunna | Hardpan plains and internal drainage tracts supporting mulga shrublands and woodlands (and occasionally eucalypt woodlands). |

## 11.2 Mineral waste characterisation

### 11.2.1 Local geology

The deposits at West Angelas lie within Archaean rocks of the Marra Mamba Iron Formation and the West Angelas Member of the Wittenoom Formation. The Marra Mamba Iron Formation has been subdivided into three members. From oldest to youngest these are:

- Nammuldi Member: overlies the Jeerinah Formation of the Fortescue Group and is characterised by poorly bedded yellow and brown chert and cherty banded iron formation (BIF) with occasional intercalated, generally thin, fissile shale partings and rare dolomite bands.
- MacLeod Member: a sequence of BIF, banded chert and chert, interbedded with a number of thick shale bands.
- Mount Newman Member: composed of alternating broad mesobands of iron oxides and white to yellow chert.

The West Angelas Member of the Wittenoom Formation overlies the Marra Mamba Iron Formation and consists predominantly of laminated pink, grey and khaki shales interbedded with lesser chert and minor BIF bands.

Tertiary and quaternary colluvium / alluvium (detritals) extend over much of the area, occasionally forming economic deposits when present in significant enough grades and

volumes. Weathering has produced a widespread regolith profile over the iron rich bedrock. A significant hydrated zone or hardcap is present, commonly 20 - 50m thick but reaches to +100m in places.

Mineral waste generated at West Angelas is subsequently categorised with respect to the geological origins of the material, namely:

- detritals;
- hydrated;
- Nammuldi Member;
- MacLeod Member;
- Mt Newman Member;
- Wittenoom dolomite; and
- West Angelas shale

### 11.2.2 Physical characteristics

The erodibility potential of waste types at West Angelas was assessed using a combination of site-specific geophysical test work and extrapolation from equivalent material at similar sites. Table 5 lists the waste material types by erodibility class and percentage of total mineral waste predicted to be generated by closure.

**Table 5: Waste material erodibility characterisation**

| Waste material type | Erodibility | Percent total waste |
|---|---|---|
| Detritals | High | 48% |
| Hydrated | Low | 16% |
| Nammuldi Member | Low | <1% |
| MacLeod Member | Low | 3% |
| Mt Newman Member | Low | 14% |
| Wittenoom dolomite | High | 11% |
| West Angelas shale | High | 7% |

The average bulk density of waste material is 2.5t/$m^3$ and loose material density of 2.02t/$m^3$ (Deposit A) to 2.06t/$m^3$ (Deposit B) with a physical swell factor (from in ground to on waste dump) of 1.25 used for volume calculations.

### 11.2.3 Geochemistry

Rio Tinto Iron Ore group has undertaken an extensive program of geochemical testing, over several years, to understand the potential for acidification and/ or metal enrichment to occur as a result of the various waste types common to mining operations in the Pilbara. The geochemical characterisation process aims to establish sulphur content, as an indicator of acid generation potential, and to undertake static (acid base accounting) and, if appropriate, kinetic testing of materials. This information is applied to the geological block model and subsequent mining model, to ensure materials with potential geochemical issues are identified prior to mining and managed, in accordance with the Rio Tinto Iron Ore (WA) Mineral Waste Management Work Practice and Spontaneous Combustion and Acid Rock Drainage (SCARD) Management Plan.

The most significant geochemical risk in Pilbara iron ore bodies is associated with sulphides, such as pyrite ($FeS_2$), which can form sulphuric acid when exposed to oxygen and water. Mt McRae Shale, the geological unit most commonly associated with pyrite and acid mine drainage in the Pilbara, is not present at West Angelas. However, pyrite can also occur in Banded Iron Formations. Other sulphate minerals present at the site, such as alunite and jarosite, can also pose a geochemical risk, albeit the risk is usually lower due to self-limiting chemical processes.

Over 150 samples from the Greater West Angelas deposits (ore and waste samples) have been submitted for Acid Base Accounting (ABA) and geochemical characterisation. For lithologies such as banded iron formation (BIF) and detrital rock types, a value of 0.3% total sulphur concentration has been adopted as the boundary value to denote

potentially acid forming (PAF) material from inert/non-acid forming (NAF) material. Samples associated with elevated-sulphate (where sulphur values may range from 0.1% to greater than 1%) have been classified as PAF-LC. A sulphur cut-off of both 0.1% and 0.3% are considered for the purpose of characterisation.

To date, approximately 82% of the samples submitted for ABA were classified as non-acid forming (NAF). Approximately seven percent of the samples submitted for ABA were classified as Uncertain and were expected to be NAF. The remaining 11% of samples were classified as potentially acid forming (PAF) or PAF in a low capacity (PAF-LC).

The potentially acid forming (PAF) samples are predominately from the Newman Member of the Marra Mamba Iron Formation. These samples are banded iron formation waste samples and the majority had visible pyrite logged. The PAF-LC samples are expected to have few sulphides present with the majority of the acid produced from the precipitation of metallic ions as hydroxides between pH 4.5 and 7.

Further analysis of sulphur values was undertaken on those rock types identified with acid-forming potential (and any related metalliferous drainage). The risk posed by the high sulphur values is determined by comparing the occurrence of sulphur levels greater than 0.1% and 0.3% against the total number of recorded drill samples for all in-pit (waste and ore) samples. These results, summarised in Table 6, suggest the risk of acid drainage being generated during the operation and / or from mineral waste materials from all deposits is low.

**Table 6: Acid-forming potential risk based on sulphur values.**

| Deposit | Sulphur levels greater than 0.1% | Sulphur levels greater than 0.3 % | AMD Risk |
|---|---|---|---|
| Deposit A | 2.9 % | 0.3 % | Low |
| Deposit E | 1.7 % | 0.2 % | Low |
| Deposit B | 7.0 % | 0.2 % | Low |
| Deposit F | 1.3 % | 0.1 % | Low |
| Deposit A West | 1.1 % | 0.1 % | Low |

A multi-element analysis was also undertaken for all drillhole samples taken from Deposits A, B, E, F and A West. Results showed that most rock types are either enriched or elevated in Fe, as correlated with the iron mineralisation associated with the ore body. Arsenic is enriched in most rock types while tin is either enriched or elevated. Other elements found to be enriched in select geological units included calcrete and dolerite from Deposit F with lead elevated, Wittenoom Formation from Deposit D with elevated levels of manganese, and waste from Deposit B, E and A West with elevated of manganese, Nammuldi Waste from Deposit B with elevated manganese.

An analysis comparing the triggers against the medium concentration of select elements in each rock type indicates that:

- All rock types have average element values lower than DEC/EPA triggers for barium and phosphorus;
- The majority of rock types have elevated mean concentrations of manganese and vanadium;
- Lead levels are relatively high in Deposit E and F; and
- Zinc levels are relatively high in Deposit B.

In general, whilst concentrations of some trace elements of potential environmental concern (e.g. arsenic, lead) were enriched or elevated in some of the sampled ore and waste materials, these elements will not necessarily mobilise into groundwater. Arsenic in particular is commonly enriched in ore and waste for many Hamersley Group deposits. Iron oxy-hydroxides such as hematite and magnetite have high sorption capacities for arsenic. Groundwater contamination with arsenic is considered to be unlikely, based on historical groundwater assessments at West Angelas and experience from similar deposits in the Pilbara. Lead is similarly unlikely to mobilise into the groundwater and cause any environmental concern. These results suggest groundwater monitoring should initially include the following elements: Fe, As, Sn, Co, Cr, Cu, Mn, Ni, Pb and Zn.

### 11.2.4 Fibrous minerals

Fibrous minerals present a health hazard if fibres of a respirable size (approximately 6 microns) become airborne and are inhaled. The most common mineral associated with fibrous minerals encountered within the iron formations present at West Angelas is riebeckite. Riebeckite is usually found in fresh, unweathered BIF. The asbestiform variety of riebeckite is crocidolite or blue asbestos. The presence of riebeckite does not necessarily pose a fibrous mineral risk but it is a precursor to crocidolite, therefore, there is a higher probability of encountering crocidolite. If it is present, crocidolite seams occur primarily within the Newman Member close to, and often overlapping into the contact between the Newman Member and the underlying Macleod Member; although crocidolite can be found anywhere within the Marra Mamba Formation where iron ore mineralisation has not occurred.

Isolated occurrences of potentially hazardous fibrous material have been intersected during geological sampling and in the upper most benches of some deposits. The Rio Tinto Iron Ore (WA) Fibrous Minerals Management Plan and West Angelas Operations Fibrous Mineral Management Plan describe and provide guidelines for the management of fibrous minerals encountered during mine production, such as the encapsulation of intersected fibrous mineral waste in 2m thickness of non-fibrous mineral waste.

The small volume of potentially fibrous material that has been mined to date has been encapsulated in the Deposit A North waste dump. Similarly, fibrous material exposed in the WEPN final pit wall has since been backfilled, and poses no risk to closure. Similarly, fibrous materials excavated during the construction if the rail loop have been appropriately disposed within nominated fibrous materials burial areas.

No Potentially Hazardous or Designated Hazardous areas are demarcated in pit walls that will form the West Angelas post-mining landform and no geological units identified with a high risk of containing potentially fibrous materials are proposed to be mined in the future.

### 11.2.5 Waste materials inventory

Mineral waste dumps were initially established outside the active mining areas. As mining progressed, mineral waste has been progressively returned to the mine void in the form of in pit backfill (to prevent post-closure exposure of the groundwater table) and internal waste dumps, some of which will join and rise above the natural topography. Table 7 lists the waste dumps that are expected to be present at the site and require rehabilitation on closure.

Waste material is managed on site through the selective placement of highly erodible material in pit or towards the centre of waste dumps where possible. As a consequence of the mine sequencing and waste material management, the waste material types that are present on the outside of the dump do not necessarily reflect the average or largest percentage of waste material type, however the waste characteristics of the materials expected to be present on the outside of the waste dump are used to guide the waste dump design.

Table 7 lists the waste dump ‘tip to’ design criteria used for the construction of existing waste dumps that will subsequently have the rehabilitation designs applied to them. These design criteria were developed in consideration of the Rio Tinto Iron Ore (WA) Landform Design Guidelines, which outlines a process for developing waste dump designs that take into account both the specific mineral wastes present in each dump, and the climatic conditions present at the site, as well as:

- location, including in pit disposal / backfill and surface water considerations;
- maximum dump height and footprint constraints;
- shape of waste dump, preferably to minimise surface area to volume ratio;
- final landform slope criteria (lift height, slope angle, minimum berm width);
- supplementary measures e.g. surface treatment for dispersive materials; and
- shaping of options for the top of the waste dump.

Design criteria for waste dumps at Deposits F and A West will be updated as the understanding of the waste material scheduling develops and the designs are finalised.

**Table 7: Inventory of waste dumps located external to the pit.**

| Waste dump | Batter slope angle (degrees) | Lift height (m) | Berm width (m) | Comments |
|---|---|---|---|---|
| Deposit A North | 37 | 20 | 68.4 | |
| Deposit A WEP | 37 | 20 | 68.4 | |
| Deposit A South | 37 | 10 / 15 / 20 | 34.2 / 51.4 / 68.4 | |
| Deposit B Western | 37 | 20 | 48.4 | Waste management will focus on dumping competent materials on the outer edge of the waste dump |
| Deposit B Eastern | 37 | 20 | 48.4 | |
| Deposit B Long term low grade | 37 | 20 | 10 | No rehabilitation design is available for this longer term stockpile. |
| Deposit E East dump | 37 | 20 | 34.2 | Material may be less competent that desired. |
| Deposit E Sth Dump 1 | 37 | 20 | 34.2 | Backfill source |
| Deposit E Sth Dump 2 | 37 | 20 | 34.2 | Backfill source |

It should be noted that some in-pit waste dumps at Deposit B may extend above the pit crest during operations. This material is expected to be used to backfill the pit post-closure, and thus waste dump designs for these locations have not been created to facilitate rehabilitation.

The rehabilitation designs are discussed in Section 16.

## 11.3 Soil

### 11.3.1 Local soils

The dominant soil types covering the project area are shallow coherent and porous loamy soils with weak pedologic development.

In the hills and rock ridges, which represent the surface expression of the Marra Mamba Iron Formation, extensive areas without soil cover occur. Those soils that do occur are shallow and skeletal. Rocks of this Formation weather very slowly, and any soil which does form tends to be transported into the surrounding valleys and plains as a result of the sparse vegetation cover and erosion force of heavy rains derived from thunderstorms and cyclones.

The soils on slopes, although having had more time to develop than the soils of the adjacent ridges, are still influenced by the parent rock and may be shallow and stony sands or loams. These soils are generally unfavourable for plant growth due to low moisture holding capacity and poor nutrient status.

On pediments, older pediplains and alluvial plains, hard alkaline red loamy soils tend to be dominant, and may be considered as the regional mature soil type. The surface of these areas may carry a layer of small gravel, which is derived from the more resistant rocks in the area.

### 11.3.2 Soil recovery

The availability of topsoil significantly improves the potential for rehabilitation success. At West Angelas, like many sites in the Pilbara, the naturally shallow or rocky soil, topography can make it difficult to recover the quantities of topsoil required to successfully rehabilitate all of the disturbed areas.

The Rio Tinto iron ore Soil Resource Management Work Practice provides guidance on soil collection and appropriate management during the operation of the mine. The procedure aims to maximise topsoil recovery and retaining soil viability and productivity to improve future success of rehabilitation programs. This is accomplished by:

- collecting more than the minimum 200mm mandated quantity of topsoil when available;
- collection of subsoil to 600mm;
- collecting additional subsoil where practicable / available;
- maintaining a soil inventory; and
- regularly reconciling the available and project soil requirements to the projected life of mine disturbance areas.

### 11.3.3 Soil inventory

A soil inventory for West Angelas is provided in Table 8 based on predicted soil recovery and requirements for 200mm of soil to be returned to rehabilitate disturbed mine areas (e.g. infrastructure areas, haul roads and waste dumps) excluding mine voids. The majority of the infrastructure at the site is located at Deposit A, resulting in the higher disturbance footprint and subsequent higher soil requirements.

As shown in Table 8, there is predicated to be sufficient topsoil for Deposit B, E, F and A West. However top soil may need to be transfer from other deposit area to support the decommissioning related rehabilitation activities at Deposit A.

**Table 8: Indicative soil balance**

| Soil required ($m^3$) | Current soil stockpile ($m^3$) | Estimated soil from future disturbance (m3) | Estimated surplus [+] or deficit [-] (m3) |
|---|---|---|---|
| 6,600,000 | 2,300,000 | 5,600,000 (top soil only) | +1,300,000 [surplus] |

| Soil required by deposit ($m^3$) | | Estimated soil recovery from future disturbance ($m^3$) | |
|---|---|---|---|
| Deposit A | 3,700,000 | 0 | 0 |
| Deposit B | 900,000 | 2,300,000 (topsoil) | 7,000,000 (subsoil) |
| Deposit E | 800,000 | 1,300,000 (topsoil) | 4,000,000 (subsoil) |
| Deposit A West | 500,000 | 1,000,000 (topsoil) | 4,000,000 (subsoil) |
| Deposit F | 700,000 | 1,000,000 (topsoil) | 4,000,000 (subsoil) |

## 11.4 Site contamination

An internal contaminated sites register is maintained for West Angelas. Twenty-one locations have been identified, predominantly consisting of low level and localised hydrocarbon contamination. None of these locations has been assessed to trigger the threshold for reporting under the *Contaminated Sites Act 2003*.

# 12. Water

## 12.1 Surface water

West Angelas lies in the upper catchment of the Turee Creek East branch[14] (Figure 7), a highly ephemeral tributary of the Ashburton River. The upper catchment has a complex drainage pattern characterised by intermittent flow and infrequent wide-spread flooding, depending on the occurrence of high rainfall events.

The surface hydrology is dominated by small sub-catchments and small first-order streams that traverse the deposits. There are few well-defined creek channels and no permanent water bodies in the local area. Mining activities have terminated most of the flows through the Deposit A, E and F area, including a small catchment area of approximately 15km$^2$ that will be terminated and / or the drainage modified as part of the Deposit F mining activities.

Flows from an unnamed creek that crossed Deposit B prior to mining have been permanently diverted to a neighbouring catchment. It is expected that this diversion will remain at closure.

## 12.2 Groundwater

The primary aquifer identified at West Angelas comprises the mineralised Mount Newman Member of the Marra Mamba Iron Formation (MMIF) and where mineralisation or weathering has occurred, the overlying Wittenoom Formation. The basal MMIF (MacLeod and Nammuldi Members) form an effective hydraulic barrier to groundwater flow. The depth to groundwater is relatively deep with groundwater flow from east to west with a relatively flat lying gradient.

Groundwater quality at Deposit A is typically slightly alkaline to neutral with pH values ranging from 7.4 to 8.2 and salinity values ranging from 490 to 820 mg/l.

Water recover is expected to begin immediately after dewatering activities are stopped. Recharge will be dominated by direct rainfall infiltration and, due to the naturally deep water table and low permeability Tertiary overburden, outside of the mine voids recharge is assumed to be very low. Predicted water recovery levels and the approximate time to recovery are listed in Table 9[15]. The difference in groundwater recovery rates and levels within deposits reflect the interaction between recharge and groundwater movement controlled by the complex folded nature of the geology (e.g. limited groundwater connectivity in “bathtub” or “bowl / pocket” structures at Deposit A and Deposit B1 pits respectively).

Final water levels are expected to be slightly lower than pre-mining levels. The catchment created by the mine void will serve to focus rainfall runoff and thus recharge, resulting in localised ponding at the base of the mine voids following heavy rainfall, which will dissipate via infiltration and evaporation shortly after the event.

**Table 9: Predicted groundwater level and approximate time to recovery.**

| Deposit | Pre-mining level (mAHD) | Recovery level (mAHD) | Time (years) |
|---|---|---|---|
| Deposit A CEPS | 640 | 630 | 30 |
| Deposit A CEPN | 660 | +610 | >100 |
| Deposit B B2 & B3 | 630 | 626 | 20 |
| Deposit B B1 | 630 | 607 | >100 |
| Deposit E | 668 | 650 | >100 |

[14] With the exception of Deposit F which straddles the catchment divide between Turee Creek and Weeli Wolli Creek.

[15] Where groundwater recovery is predicted to take more than 100 years, the recovery level after 100 years is provided. Recovery levels are based on the continuation of current climate conditions.

## 12.3 Turee B borefield

The Turee B borefield abstracts water from a hydrated limonitic / goethitic hardcap (pisolite) and the underlying fractured bedrock (Brockman, Weeli Wolli, Wongara and Boolgeeda Formations and the Turee Creek Shale). The borefield is extensively monitored, in accordance with its license operating conditions, and based on the water levels recorded, groundwater chemistry and the results of a tree stress programme, there is no data to suggest the aquifer and its surrounds are being adversely impacted by the current amount of abstraction. As water demand from the Turee B borefield is not expected to increase over the life of the mine, decommissioning of the borefield is the only rehabilitation requirements anticipated on closure.

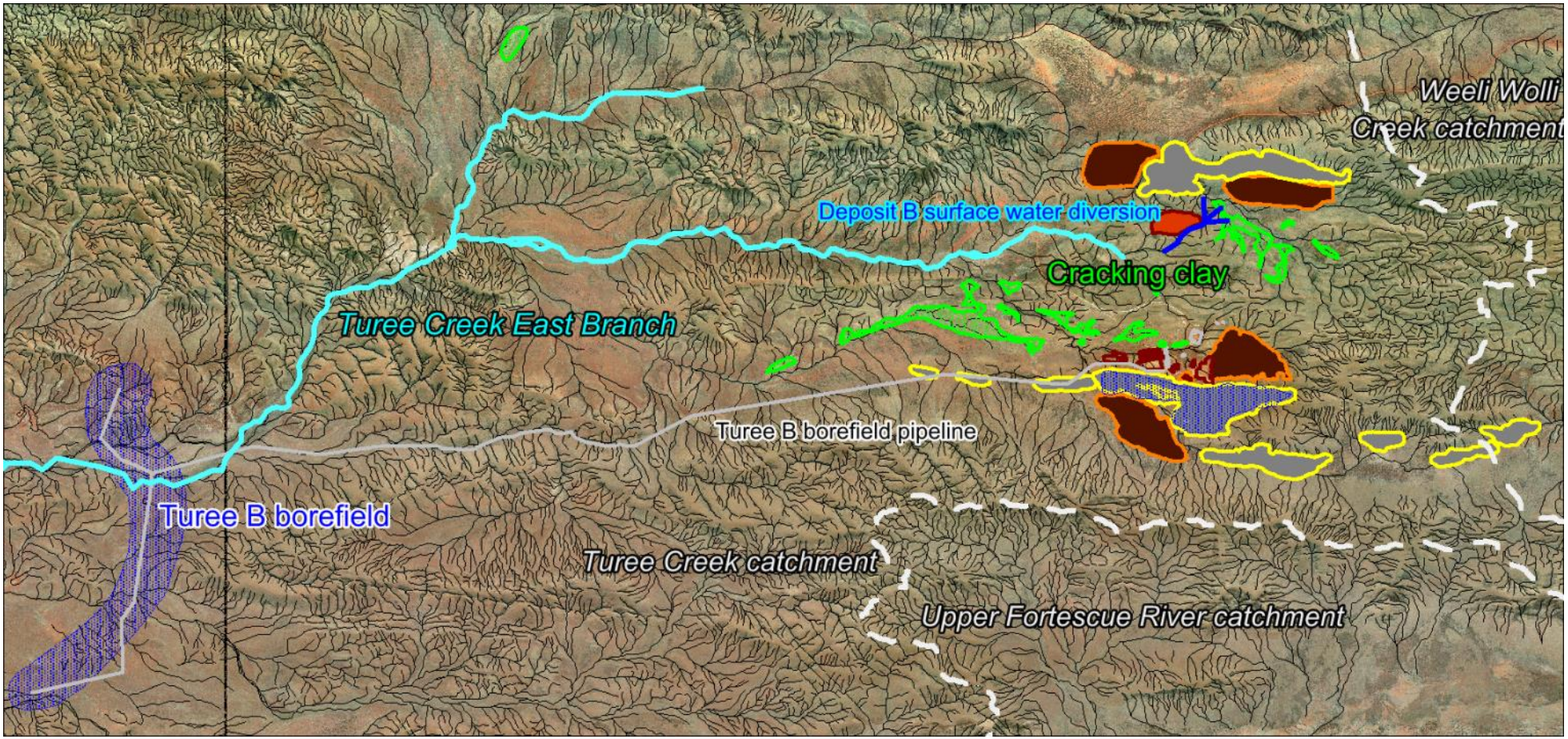


**Figure 7: Creek and associated drainage network at West Angelas. The distribution of the cracking clay priority ecological community is highlighted in green, for reference. (Waste dumps still undergoing design reviews at Deposits E, F and A west are not shown in this figure.)**

# 13. Biodiversity

Rio Tinto Iron Ore undertakes regular surveys at established reference sites throughout the life of its mines to ascertain temporal differences in vegetation composition and faunal distribution in reference sites across the Pilbara.

It is recognised that West Angelas has a great diversity of habitats and flora for its size because of a variety of relief and geological types. However, the conservation status of flora and fauna species, populations and fauna habitat is not expected to be impacted by the mining activities at West Angelas.

Baseline surveys undertaken at West Angelas and the surrounding environment, prior to and during mining, include (as captured in Appendix B Closure knowledge database):

- terrestrial vegetation and flora; and
- terrestrial and subterranean fauna (including Short-Range Endemic (SRE) invertebrates, troglofauna and stygofauna).

This data has been used to identify biodiversity / ecosystem values of relevance to the closure of West Angelas and inform the rehabilitation process.

## 13.1 Habitat

A habitat is made up of physical factors such as soil, moisture, range of temperature, shelter and availability of light as well as biotic factors such as vegetation, availability of food and the presence of predators. Habitats provide a simple method of dividing the land into areas with common characteristics.

The biodiversity significance of a habitat may subsequently be measured in terms of the range of habitat types, habitat coverage or with respect to the diversity or rarity of species within the individual habitats. Similarly, the consequence of mining may be strategically assessed through an understanding of the relative magnitude of habitat loss, linkage between habitats and / or the anticipated changes as a consequence on introducing of new habitat.

Eight broad habitat types were mapped at West Angelas prior to mining. Characteristics of these habitat types are provided in Table 10 and include:

- Hill habitats including,
  - hilltop, hillslope, ridge or cliff;
  - mesa top; and
  - major gorge and gully;
- Valley habitats including,
  - footslope or plain;
  - acacia woodland;
  - mulga woodland – these areas are considered to be environmentally sensitive areas; and
  - cracking clay – these areas are considered to be priority ecological communities;
- Drainage habitats: creek.

Plain, hilltop and acacia woodland are the dominant habitat types in the area. All of the habitat types are expected to be present in the environment, immediately outside the disturbance areas, on closure.

Of the habitat types, hilltop, gully, cracking clay and creek habitats are of high value due to the diversity of microhabitats and potential to support conservation significant fauna species. Mesa top and mulga woodland habitat is considered to have moderate habitat value due to the specialty habitat or number of fauna that may utilise the area, while plain and acacia woodland have the lowest value. In contrast, cleared habitat, created through mine disturbance, provides little food, shelter, water or any other life essential and is considered to have little to no habitat value.

Re-introduction of fauna is not considered as part of this closure plan. Instead, natural migration of fauna species into rehabilitated land is encouraged by creating habitats with similar composition to pre-mining communities in appropriate locations and with consideration of the post-closure soil and landforms design.

Habitat elements that are considered as part of the closure landform design include:

- vegetation known to provide preferred food or shelter preference;
- retaining and replacing woody debris;
- rapid generation and retention of leaf litter using small-scale topography (e.g. furrows created from ripping);
- introducing or leaving rocky features such as oversized waste burden or scree slopes;
- creating greater depths of friable soil (or suitable mineral wastes) for burrowing fauna;
- preserving connectivity with unmined areas, and maintaining the quality of these habitats; and
- managing feral predators and herbivores across both reference and rehabilitated areas.

**Table 10: Habitats at West Angelas.**

| Type | Basic description |
|---|---|
| **Hill habitats** | |
| Hilltop | Hills, ridges, plateaux remnants, gorges and breakaways of varied geological origin. Soil is generally skeletal sandy clay loams with greater than 80% stony detrital material.<br>Under natural conditions this habitat zone is characterised by a scattered overstorey of Snappy gum *Eucalyptus leucophloia* and mulga (*Acacia aneura* complex) isolated trees over sparse shrubland of a combination or selection of *Senna artemisioides* subsp. *artemisioides, S. artemisioides* subsp. *filifolia, Ptilotus rotundifolius, Tribulus suberosus, Eremophila fraseri* and *Acacia ancistrocarpa* sparse shrubland to isolated shrubs over *Triodia pungens* hummock grassland. Rocky, sheltered ridges and breakaways provide a suite of specialist plants or species more typical of lowlands.<br>This habitat creates a diverse array of microhabitats and refugia. The habitat often contains rock shelters in the form of overhangs, cracks, crevices, caves and areas for water to pool during the wet season. Vegetation provides microhabitats in the form of logs, debris and hollows.<br>This habitat zone will be present in undisturbed areas of the mine and may evolve around the edge of the disturbed mine area especially where the pit shell intersects local hills after erosion processes occur. However the characteristics of this habitat are not compatible with the closure landform is unlikely to be restored or introduced as part of the rehabilitation activities. |
| Mesa top | Mesa top habitat is distinguished by its elevated plateau topography.<br>This habitat is characterised by *Eucalyptus leucophloia, E. gamophylla, Acacia pruinocarpa* and mulga (*A. aneura* complex) open woodland to sparse trees, over *A. maitlandii, A. hamersleyensis, Keraudrenia velutina* and *Senna glutinosa* subsp. *glutinosa* open shrubland, over *Triodia pungens, T. longifolia* and/or *T. wiseana* open hummock grassland<br>This habitat is characterised by a low diversity due to the elevation and therefore the isolation from accessible surrounding habitats. However, invertebrate fauna can be quite diverse and specialised as a result of this isolation.<br>This habitat zone will not be substantially disturbed by mining activities and will be present in undisturbed areas to the east of Deposit B. The characteristics of this habitat are not compatible with the closure landform is unlikely to be restored or rehabilitated as part of the rehabilitation activities. |
| Major gorge | Very steep topography with an irregular surface with little exposed soil. The soil, when available, is sandy to sandy-clay.<br>This habitat commonly includes *Acacia aptaneura* open woodland over *Ptilotus obovatus* isolated shrubs over *Themeda triandra* and *Eriachne* sp. open tussock grassland and *Triodia pungens* isolated hummock grasses. *Astrotricha hamptonii, Ficus brachyopoda* and *Cyperus cunninghamii* are species found only in the major gorge are considered descriptive of this habitat type, although not dominant.<br>This habitat creates a diverse array of microhabitats and refugia. The habitat often contains rock shelters in the form of overhangs, cracks, crevices, caves and areas for water to pool during the wet season. Vegetation provides microhabitats in the form of logs, debris and hollows.<br>This habitat zone will be present in undisturbed areas of the mine. The characteristics of this habitat are not compatible with the closure landform is unlikely to be restored or rehabilitated as part of the rehabilitation activities. |

| Type | Basic description |
|---|---|
| **Valley habitats** | |
| Plains | Low and occasionally slightly undulating alluvial plains including outwash areas and broad drainage basins. Under natural conditions soils often consisting of sandy-clay soils covered by rocky lag gravel.<br>The habitat is characterised by *Eucalyptus leucophloia, E. gamophylla, Corymbia hamersleyana, A. pruinocarpa, A inaequilatera* and species in the *A. aneura* complex open woodland to sparse trees over *Acacia* spp.*, Eremophila* spp., *Ptilotus* spp., *Senna* spp. and *Solanum lasiophyllum* open shrubland over *Triodia* spp. open hummock grassland.<br>The habitat includes minor drainage lines, where *T. longifolia, Gossypium robinsonii and Acacia ancistrocarpa* are characteristic.<br>This habitat type contains limited microhabitats with the dominant Acacia species providing no tree hollows, few logs, limited leaf litter and sparse vegetation. SRE invertebrate species usually comprise mygalomorph (trapdoor) spiders, scorpions, pseudoscorpions and isopods. Most SRE invertebrates prefer the southern footslopes where sun exposure is reduced and the level of moisture under shrubs and trees is increased.<br>This habitat zone will be present in undisturbed areas of the lease. Characteristics of this habitat may be suitable for rehabilitation planning and could be considered where there is the opportunity for deep soils to develop, i.e. on waste dumps. |
| Acacia woodland | Flat with no or very small drainage channels, under natural conditions soils often consist of a clay loam with continuous layers of small ironstone pebbles on the surface.<br>The habitat is characterised by open to medium dense woodland with a tree stratum of mulga (*Acacia aneura* complex) and scattered *Acacia pruinocarpa*, over *Acacia maitlandii* and *Ptilotus* sp. sparse shrubland, over *Triodia wiseana* and *T. pungens* open hummock grassland dominated the mixed *Acacia* woodland habitat.<br>Similar to the plains habitat, this habitat type contains limited microhabitats with the dominant Acacia species providing no tree hollows, few logs, limited leaf litter and sparse vegetation. However, avifauna is most diverse after significant rainfall, and when acacia shrubs and trees are flowering.<br>This habitat zone will be present in undisturbed areas of the lease. Characteristics of this habitat may be suitable for rehabilitation planning and could be considered on flat areas that sustained mixed acacia woodland vegetation prior to disturbance. |
| Mulga woodland | Flat areas dominated by overland surface water flows, rather than concentrated flow along drainage lines, following very heavy rainfall. Soils are typically comprised of sandy-clay with no rocks.<br>This habitat consists of both groved and banded mulga, where different species of the *Acacia aneura* complex were present in a closed woodland, over *Ptilotus obovatus* and juvenile mulga trees sparse shrubland, over *Maireana* sp. and *Salsola australis* isolated herbs and *Aristida* sp. and *Cymbopogon obtectus* isolated tussock grasses creating distinct micro-habitats that include dense leaf litter and shaded zones.<br>Similar to the acacia woodlands habitat, this habitat type contains limited microhabitats with the dominant Acacia species providing no tree hollows, few logs, limited leaf litter and sparse vegetation. Avifauna is most diverse after significant rainfall, and when acacia shrubs and trees are flowering.<br>This habitat zone will be present in undisturbed areas of the lease. Characteristics of this habitat may be suitable for rehabilitation planning and could be considered on flat areas that sustained mulga woodland vegetation prior to disturbance. |

| Type | Basic description |
|---|---|
| Cracking clay | Characterised by sand-clay to clay soils with an undulating surface caused by crabholes and gilgai. Rocks and pebbles were very rare and when present, the rock type was consistently ironstone.<br>This habitat supports very few trees or tall shrubs and is characterised by open and sparse low vegetation with approximately half of its area being bare ground. Isolated shrubs of *Salsola australis, Boerhavia paludosa* and *Ptilotus nobilis* subsp. *nobilis* were present over open tussock grassland of *Aristida* sp., *Brachyachne* sp. and *Astrebla pectinata.*<br>This habitat is identified as Priority 1 ecological community due to its restricted distribution across the Pilbara, and contains species which are both rare and edaphically restricted (i.e. distribution is influenced by the soil rather than by the climate).<br>This habitat zone will be protected as far as practicable during mining activities and will be present in undisturbed areas to the north of Deposit A West and south of Deposit B. The soil profile required to restore this habitat is not compatible with the closure landform; although, following further investigation, opportunities may exist to establish a community in an appropriate locations by relocating habitat scheduled to be destroyed (e.g. areas under Deposit B waste dumps). |
| **Drainage habitats** | |
| Creek | A linear habitat characterised by regular surface water flows, defined banks and associated riparian vegetation corridor. The creek habitat includes areas that are periodically flooded due to high surface water flow volumes (floodplains).<br>Vegetation is characterised by open woodland of *Eucalypts victrix, Acacia citrinoviridis* and *Acacia aptaneura*, over *Senna artemisioides* subsp. *oligophylla*, *Rhagodia eremaea*, *Ptilotus obovatus*, *Tephrosia rosea* and Malvaceae spp. shrubland over *Themeda triandra* and *Bothriochloa* sp. sparse tussock grasses and/or *Triodia pungens* sparse hummock grasses.<br>Creek habitats act as wildlife corridors that help flora and fauna disperse across the landscape. There is a high diversity of microhabitats including logs, debris, tree hollows and soft soils, as well as temporary and permanent pools.<br>This habitat zone will be present in undisturbed areas outside of the mine. Disturbed creek habitat, i.e. access roads that cross creeks and discharge related infrastructure, will be rehabilitated with the aim of returning the land to functional creek habitat. |

## 13.2 Fauna

### 13.2.1 Priority fauna

Species have been identified as present at or near West Angelas and have biodiversity value because of their rare and / or threatened status, as listed in Table 11. Invertebrate fauna potentially harbouring short-range endemics were also recorded. These include mygalomorph and araneomorph spiders, centipedes, pseudoscorpions and scorpions.

The Grey Honeyeater (*Conopophila whitei*) and the Ghost Bat (*Macroderma gigas*) are identified as Specially Protected Fauna. These species are managed through the operations environmental management plan with the aim of minimising disturbance of their habitat. No further management is proposed as part of this closure plan.

Table 10 and Table 11 suggest species associated with plains and acacia woodlands habitats have the potential to benefit from the rehabilitation of mine, as a consequence of returned or expanded habitat post-closure.

### 13.2.2 Subterranean fauna

Subterranean fauna are animals that inhabit underground habitats and include:

- stygofauna - obligate, groundwater dwelling aquatic fauna,
  - including occasional hyporheos stygophiles, i.e. the larvae of aquatic insects, are species considered to be either restricted to the hyporheic zone, the region beneath and alongside a stream bed where there is mixing of shallow groundwater and / or surface water, and
- troglofauna - obligate, subterranean dwelling fauna occurring in the unsaturated profile above the water table.

Stygofauna and troglofauna are known to occur in a range of habitats in the Pilbara region, but can potentially have restricted distributions based on their evolutionary history and specialised habitat requirements. Regional sampling at West Angelas has indicated the presence of a high density and diversity of stygofauna in the area. However, the presence of stygofauna at the sampling locations is variable, with four out of seven sampling campaigns failed to detect the presence of stygofauna. Stygofauna have yet to be detected within active mining areas.

No troglofauna have been recorded.

Disturbance to subterranean fauna and their associated habitat during operations is not anticipated to be significant, such that no management of subterranean fauna is proposed as part of the closure plan.

### 13.2.3 Common species

Common fauna species that are considered to be important indicators of rehabilitation success, and therefore have biodiversity value, include:

- micro-organisms brought into rehabilitated areas within re-spread topsoils;
- invertebrates, especially ants and parasitic wasps; and
- vertebrates.

Invertebrates have a major role in the success of rehabilitation efforts because they facilitate a variety of ecosystem processes, such as litter decomposition and nutrient cycling, herbivory, seed dispersal, soil aeration and drainage, pollination and provision of a source of food for vertebrate predators. Invertebrates can be encouraged by providing areas of thick, widespread litter cover over part of the area, logs and standing dead wood.

Vertebrates are usually the last to recolonise, once complex vegetation assemblages and invertebrate prey are established.

**Table 11: Significant fauna and its relationship to habitat across the West Angelas mine lease.**

| Fauna species | Conservation status WA | EPBC Act status | Habitat occurrence | Comments |
|---|---|---|---|---|
| *Dasyurus hallucatus* (northern quoll) | Schedule 1 | Endangered | Gullies<br>Disturbed | Habitat for this species is rocky ridgelines and rocky gorges. |
| *Rhinonicteris aurantia* (Pilbara orange leaf-nosed bat) | Schedule 1 | Vulnerable | Gullies<br>Hilltop | Recoded in three locations within 30km of the study. Caves near water provide suitable roosts. |
| *Liasis olivaceus barroni* (olive python) | Schedule 1 | Vulnerable | All hill habitats | Widespread in rocky areas, showing a preference for rocky habitats near water, particularly rock pools |
| *Falco hypoleucos* (grey falcon) | Schedule 1 | Vulnerable | Acacia woodland<br>Mulga woodland<br>All drainage habitats | Previously recorded close to area. Ranges across habitats in search of food. Prefers lightly wooded coastal and riverine plains. |
| *Ramphotyphlops ganei* | Priority 1 | - | All habitats | Prefers moist gorges. |
| *Underwoodisaurus seorsus* (Pilbara barking gecko) | Priority 1 | - | All hill habitats | Recorded in area. Prefers rocky gorges and rock piles. |
| *Falco peregrinus* (peregrine falcon) | Schedule 4 | - | All habitats | Ranges across habitats in search of food |
| *Leggadina lakedownensis* (short-tailed mouse) | Priority 4 | - | All | Recorded in area. Known to occur across all habitats, from sandy soils and cracking clays to stony ranges. |
| *Pseudomys chapmani* (western pebblemound mouse) | Priority 4 | - | All hill habitats | Recorded in area. Habitat for this species is rocky, hummock grasslands, with little or no soil. The western pebble-mound mouse occupies burrows beneath mounds of pebbles. Mounds are most common on the spurs and lower slopes of ridges |
| *Sminthopsis longicaudata* (long-tailed dunnart) | Priority 4 | - | All hill habitats | - |
| *Macroderma gigas* (ghost bat) | Priority 4 | - | Gullies<br>Hilltop | Located in caves near Deposit E and Deposit B. Roost in caves, rock piles and abandoned mines. Will travel 2 km from roost to hunt. |
| *Ardeotis australis* (Australian bustard) | Priority 4 | - | Plains | Recorded in area. Habitat preferred by this species lightly wooded country next to daytime shelter of thickets or long grass. |
| *Burhinus grallariuss* (bush stone-curlew) | Priority 4 | - | All valley habitat | Recorded in area. Habitat preferred by this species is tussock grassland, Triodia hummock grassland, grassy woodland and low shrublands |
| *Conopophila whitei* (grey honey-eater | | | Mulga woodlands | Potentially threatened due to the destruction of its mulga habitat at West Angelas |

| Fauna species | Conservation status WA | EPBC Act status | Habitat occurrence | Comments |
|---|---|---|---|---|
| *Merops ornatus* (rainbow bee eater) | | Migratory | All valley habitats | Recorded in area. Found within open forests, woodlands and shrublands, and cleared areas. Open pit walls may be utilised to build nesting tunnels |
| *Apus pacificus* (fork-tailed swift) | | Migratory | All drainage habitats | Recorded in areas. Nomadic, almost entirely aerial lifestyle over a variety of habitats; associated with storm fronts. |

**Table 12: Significant flora and its relationship to habitat across the West Angelas mine lease.**

| Flora taxon | Conservation status WA | Habitat comments |
|---|---|---|
| *Lepidium catapycnon* | Threatened | Skeletal soils. Hillsides |
| *Brunonia* sp. Long hairs (D.E. Symon 2440) | 1 | Along creeklines and floodplains in clay or sandy clay |
| *Eragrostis* sp. Mt Robinson (S. van Leeuwen 4109) | 1 | Red brown skeletal soils, ironstone. Steep slopes, summits |
| *Eremophila* sp. Hamersley Range (K. Walker KW 136) PN | 1 | Summit of hill, high in landscape, steep rock slopes and scree, skeletal brown-red soil over massive banded ironstone of the Brockman Iron Formation |
| *Eremophila* sp. West Angelas (S. van Leeuwen 4068) | 1 | High in landscape, summit of hill, gently undulating to steep terrain, skeletal red gritty soil over massive banded iron of the Brockman Iron Formation |
| *Grevillea* sp. Turee (J. Bull & G. Hopkinson ONS JJ 01.01) PN | 1 | Breakaways and scree slopes, orange-brown loam soils |
| *Josephinia* sp. Marandoo (M.E. Trudgen 1554) | 1 | Outer edge of creek vegetation. Soil: Orange-brown (terracotta) coloured clay-loam |
| *Rhodanthe ascendens* | 1 | Clay |
| *Tetratheca fordiana* | 1 | Shale pocket amongst ironstone |
| *Teucrium pilbaranum* | 1 | Crab hole plain in a river floodplain, margin of calcrete table |
| *Vittadinia* sp. Coondewanna Flats (S. van Leeuwen 4684) | 1 | Flat plain. Red sandy clay loam. |
| *Aristida lazaridis* | 2 | Sand or loam |
| *Eremophila forrestii* subsp. Pingandy (M.E. Trudgen 2662) | 2 | Flat terrain, low in landscape, base of broad valley, stony gibber plain above shallow drainage line, red clay loam |
| *Euphorbia clementii* | 2 | Sandplains, gravelly hillsides, stony grounds |
| *Hibiscus* sp. Gurinbiddy Range (M.E. Trudgen MET 15708) PN | 2 | Near summit of hill, high in landscape, skeletal red brown stony soil over massive ironstone of the Brockman Iron Formation |

| Flora taxon | Conservation status WA | Habitat comments |
|---|---|---|
| *Oxalis* sp. Pilbara (M.E. Trudgen 12725) | 2 | Gully. Brown red loam, cobbles and pebbles |
| *Pilbara trudgenii* | 2 | Skeletal, red stony soil over ironstone. Hill summits, steep slopes, screes, cliff faces |
| Spartothamnella *puberula* | 2 | Rocky loam, sandy or skeletal soils, clay. Sandplains, hills |
| *Acacia effusa* | 3 | Stony red loam. Scree slopes of low ranges |
| *Acacia* aff. *subtiliformis* | 3 | On rocky calcrete plateaus |
| *Dampiera metallorum* | 3 | Rocky ledges and breakaways with loose scree material in lower section of plot. |
| *Goodenia* sp. East Pilbara (A.A. Mitchell PRP 727) | 3 | Red brown clay soil, calcrete pebbles. Low undulating plain, swampy plains |
| *Indigofera* sp. Gilesii (M.E. Trudgen 15869) | 3 | Pebbly loam amongst boulders & outcrops. Hills |
| *Oldenlandia* sp. Hamersley Station (A.A. Mitchell PRP 1479) | 3 | Cracking clay, basalt. Gently undulating plain with large surface rocks, flat crabholed plain |
| *Olearia mucronata* | 3 | Schistose hills, along drainage channels |
| *Rhagodia* sp. Hamersley (M. Trudgen 17794) | 3 | Broad plain at the base of hills (enclosed on all sides). Red brown clay/ loam. Ironstone pebbles |
| *Rostellularia adscendens* var. *latifolia* | 3 | Ironstone soils. Near creeks, rocky hills |
| *Sida* sp. Barlee Range (S. van Leeuwen 1642) | 3 | Skeletal red soils pockets. Steep slope. |
| *Themeda* sp. Hamersley Station (M.E. Trudgen 11431) | 3 | Red clay. Clay pan, grass plain |
| *Triodia* sp. Mt Ella (M.E. Trudgen 12739) | 3 | Light orange brown, pebbly loam. Amongst rocks & outcrops, gully slopes |
| *Acacia bromilowiana* | 4 | High in landscape, summit of hill and on steep slope, skeletal red gritty soil over massive basalt type rock |
| *Goodenia nuda* | 4 | Wide alluvial plain or creek beds. Red brown clay loam, ironstone. |

## 13.3 Vegetation

### 13.3.1 Priority flora

Table 12 describes the Threatened and Priority flora that have been identified at or near the West Angelas operations and have biodiversity value because of their rare and / or threaten status.

The inclusion of rare and threatened species in rehabilitation programmes is limited by:

- habitat preference (preference for drainage lines, gullies, calcretes or other habitat not suitable or similar to those likely to be present in the rehabilitation landscapes);
- abundance – very few populations or small populations from which to source seed;
- difficult taxonomy / unresolved taxonomy issues and thus status of species highly uncertain; and / or
- growth form – e.g. short lived annual species with preference for growth under woodland canopies.

Other issues include the availability of seed at the time when rehabilitation occurs and seed dormancy.

In consideration of these issues, six species from Table 12 have been identified that could be considered in future rehabilitation programmes:

- *Acacia bromilowiana*;
- *Acacia subtiliformis;*
- *Grevillea* sp. Turee*;*
- *Indigofera* sp. Gilesii;
- *Sida* sp. Barlee Range; and
- *Themeda sp.* Hamersley Station (M.E. Trudgen 11431).

Propagation options for *Acacia bromilowiana* are under investigation to determine how to include this species in rehabilitation activities.

The suitability of *Acacia subtiliformis* for rehabilitation purposes is still under investigation. This species prefers flat areas near calcrete geology. These conditions may be limited within the closure landform.

*Grevillea sp. Turee* is suitable for rehabilitation on waste dumps, and could be easily integrated into rehabilitation activities. *Indigofera gilesii* subsp. *Gilesii* prefers broken rocks in areas where water may pond for short times, habitat characteristics that will also be common within the closure landform. Inclusion of *Grevillea sp. Turee* and *Indigofera gilesii* subsp. *Gilesii* are currently limited by seed collections issues due to the small populations present in the Pilbara.

Inclusion of *Sida* species Barlee Range is currently limited by seed collections issues and potential seed dormancy, but is otherwise expected to be suitable for revegetation in any habitat.

*Themeda* species Hamersley Station has a preference for heavy, clay soils. This restricts potential use of this species to areas with a high soil fine fraction. These conditions may develop in the closure landform in internally draining pit backfilled areas. However, conditions will need to be verified in the field, after landform shaping, to confirm suitability for rehabilitation purposes.

## 13.4 Progressive rehabilitation results

Land disturbed at West Angelas to date has been associated with mine pits for ore access, waste dumps and transport access and is at 65% of the total approved site disturbance at end of 2013. To date rehabilitation has been predominantly associated with construction laydown areas; borrow pits and tracks, which were cleared during the construction phase of the mine. A rehabilitation trial has been undertaken on two waste rock dumps in 2012 covering 7.5 ha. The rehabilitation trial is to confirm erodibility modelling outcomes that are to be used for future closure of waste dumps at Deposit A.

### 13.4.1 Borrow pits and rail loops

Rehabilitation at most of the West Angelas borrow pits and rail loop sites was undertaken between 2000 and 2003. Established monitoring transects include:

- Five borrow pits at the highway end of access road (Highway 1-5);
- Four rail loop rehabilitation areas (Rail Loop 1a, 1b, 2 and 3);
- Three borrow pits adjacent to the airstrip (Airstrip 1-3); and
- Three reference transects C7, C8 and C9.

The vegetation is well established (Figure 8), and in most cases sites compare favourably with one or more of the reference sites. Over half the species present in the rehabilitation sites were recorded in three reference sites. They include a range of perennial shrub and grass species. The absence of some species from rehabilitation may reflect pre-mining site differences as well as rehabilitation establishment and survival.

Other species were present in rehabilitation but not in reference sites. Likely reasons are the greater sampling effort in rehabilitation (i.e. more sites) and the increased presence of early colonizing species. The number of species in the rehabilitated sites is expected to increase with time through natural re-colonisation from surrounding areas.

All sites appear stable; and some sites may be nearing a stage where signoff could be considered.



**Figure 8: Rehabilitation progress at Highway 3.**

### 13.4.2 Waste dumps

Two waste dumps areas at Deposit A South waste dump (SouthWD) and North waste dump (EastWD) were rehabilitated in 2012. The South waste dump (Figure 9) area is a 6 ha portion of the lower lift, and North waste dump (Figure 10) area is a 1.5 ha section of the lower lift. Reference sites have been established in unmined areas that consist of similar vegetation, soil and terrain characteristics of the area to be rehabilitated.

*Triodia* species appear to be establishing well and in line with abundance recorded from reference sites. Rehabilitation between the sites is variable, with the flattest site recording the highest total plant numbers, spinifex establishment and cover of perennials.



**Figure 9: Rehabilitation progress at Deposit A South waste dump (2013) 1 year after seeding.**



**Figure 10: Rehabilitation progress at Deposit A North waste dump (2013) 1 year after seeding.**

# 14. Community

## 14.1 Cultural heritage

Note some social data used to inform closure decisions is gathered in confidence. This information remains confidential to Rio Tinto and the representative bodies, management committees and members of the relative interest groups. This information cannot be disclosed to any other person or organisation without the written permission of all of these

groups with the exception of State and Commonwealth agencies (e.g. Department of Aboriginal Affairs [DAA], EPA, DMP) for the purposes of demonstrating compliance with various regulatory and other requirements. Similarly some cultural heritage values information is not available to the general public and is unable to be released.

### 14.1.1 Relevant Aboriginal groups

The Yinhawangka (Gobawarrah Minduarra Yinhawanga) People and Ngarlawangga People are the traditional custodians of the land identified in this closure plan.

Yinhawangka is represented by Yamatji Marlpa Aboriginal Corporation (YMAC) for cultural heritage matters; Ngarlawangga is represented by Ngarlawangga Aboriginal Corporation assisted by Ngurra Barna Aboriginal Corporate Services. Members of these corporations are geographically dispersed with key locations being Wakathuni and Bellary near Tom Price, Onslow, Roebourne, Karratha and Port Hedland.

Consultation with regards to closure has been limited to date. Topics that require consultation include the on-going access to heritage sites post closure and the ultimate resting place of any artefacts salvaged.

### 14.1.2 Ethnographic and archaeological values

Archaeological and ethnographic surveys have been undertaken at West Angelas since 1977. All surveys were undertaken with the full participation and involvement of representatives from the Yinhawangka people.

Aboriginal heritage sites at West Angelas consist of rock shelters, stone artefact scatters, scarred trees, grinding patches, and mythological sites. One rock shelter, located above Deposit E, has been designated as a “Rights Reserved”[16] area as it holds special significance to the Yinhawangka people. Management of this site during operations is currently subject to ongoing discussion. If preservation of the site is deemed the most appropriate action, the long term stability of the pit wall below the rock shelter will need to be addressed through the closure plan.

## 14.2 Local community

The area surrounding the mine is unallocated crown land with no homesteads or Aboriginal communities in close proximity. The nearest town, Newman, is located approximately 120km south-east of West Angelas.

West Angelas operates solely as a Fly-In Fly-Out (FIFO) operation. The majority of the workforce flies in and out of the privately owned airstrip adjacent to the mine village. As a result, there is little direct social interaction between the workforce and any surrounding local communities.

## 14.3 Workforce

West Angelas is operated wholly as FIFO operations, with no personnel residing in the Pilbara. The majority of staff is flown directly from Perth to the site operated airport, with small numbers also flying directly from Busselton and Broome. Personnel are housed on site, in a fully serviced accommodation facility that will be decommissioned as part of this closure plan.

Mining activities are anticipated to continue at a similar rate within the wider region after the West Angelas mine ceases to operate. Thus employment opportunities and mine related services are not anticipated to be significantly impacted by closure of the mine.

[16] A Rights Reserved site is an area of recognised significance to the Traditional Owner group, where the group does not consent to a section 18 AHA approval.

# Closure management strategies

This chapter documents the strategies that are currently in place to manage various aspects that need to be considered when closing a mine site. It also documents strategies to manage any additional aspects that have been identified as being significant for this site specifically.

The strategies will be converted into detailed plans as part of the Decommissioning Plan, developed five years prior to closure.

## 15. Removal of infrastructure

Decommissioning is anticipated to commence at the cessation of mining activities, as most areas of the mine, mine equipment and infrastructure will be fully utilised until the end of the mine life. However, as with progressive rehabilitation, opportunities to decommission areas in advance and facilitate rehabilitation will be reviewed through the mine planning process.

Rio Tinto iron ore has generic strategies for the removal of infrastructure, and develops location specific decommissioning plans as part of the decommissioning study, conducted 5 years prior to closure. Strategies involve:

- negotiating with Government prior to the removal of infrastructure as required under State Agreement requirements;
- actively seeking opportunities to recycle or reuse infrastructure that is to be removed;
- removing any environmentally hazardous materials in accordance with Controlled Waste Regulations; and
- where recycling and reuse opportunities are not available or viable, demolishing inert infrastructure and burying it onsite.

The decommissioning requirements for infrastructure at West Angelas are outlined in Table 13.

**Table 13: Decommissioning requirements for West Angelas.**

| Category | Strategy |
|---|---|
| General | • Any equipment, steel structures or material that is not suitable for reuse are to be completely removed to an approved disposal site.<br>• If encountered, any asbestos-containing building product or pipe work is to be disposed appropriately. |
| Above ground structures (e.g. buildings, tanks) | • Brick, block work and steel frame structures are to be dismantled and salvaged or appropriately disposed.<br>• Any container or tank that has held hazardous materials is to be drained/emptied and then disposed.<br>• Bullet tanks and storage tanks 4 m diameters and less will be disposed of whole. Bins and storage tanks greater than 4 m diameter will be cut into transportable sizes for removal. |
| Reinforced soil walls | • Remove any structures, footings, slabs and equipment supported by the wall and its backfill.<br>• Dismantle wall and remove backfill back to a natural surface profile. Any part of the wall that will be more than 1m below the finished ground surface can remain in place. |
| Concrete or sleeper-type retaining walls | • Remove any structure, footings, slabs and equipment supported by the wall.<br>• Excavate soil from back of wall to a depth sufficient to allow the next two steps to be safely accomplished. |

| Category | Strategy |
|---|---|
| | • Remove any tiebacks and deadmen that are within 1 m of the finished ground level. |
| Ground slabs | • Remove all attached steelwork, block work, services and equipment.<br>• Break up and dispose of the concrete and full removal is practicable / required.<br>• Otherwise leave the slab in place and cover with earth to a natural profile, and with minimum cover of 1 m. |
| Footings and associated pedestals | • Remove all attached steelwork and equipment.<br>• If the footing and associated pedestals are less than 2 $m^3$, remove and dispose of them.<br>• Otherwise cut and remove pedestals if required, and cover with earth to a natural profile, and with minimum cover of 1 m. |
| Above-ground concrete plinths (e.g. pump plinths) and structures (e.g. crusher blocks) | • Remove all attached steelwork and equipment.<br>• Where practicable, remove concrete intact to disposal.<br>• Otherwise, break concrete items and remove to disposal. |
| Culverts | • Remove all fill back to natural surface profile.<br>• Remove culvert. |
| Sedimentation basins, ponds and reservoirs | • Dispose of liquid and sediments prior to deconstruction.<br>• Break up and remove all concrete. |
| Roads and hardstand areas | • Remove any bituminous material to a disposal pit. |
| Below ground infrastructure | • Services and infrastructure less than 1 m below ground level to be removed.<br>• Services and infrastructure greater than 1m below ground level to be left in situ. |

# 16. Landform design

## 16.1 Waste dump rehabilitation design

The Rio Tinto Iron Ore (WA) Landform Design Guidelines outline a process for developing waste dump designs that take into account both the specific mineral wastes present in each dump and the climatic conditions present at the site. The guidance aims for waste dumps external to mine voids on closure to have slopes with a predicted average erosion rate (averaged over the entire slope length) of <5 t/ha/y, together with a predicted maximum erosion rate at any point on the slope of <10 t/ha/y, such that rilling, and consequently gullying potential will be minimised.

The guidance highlights that design criteria for stable landforms differ depending on the geological origin of the mineral wastes generated. As such, the parameters used to design each waste dump constructed are considered individually. Table 14 describes the proposed rehabilitation landform designs for the waste dumps at West Angelas. These designs are subject to ongoing review and update, following verification of the material characteristics presenting on the outside of the waste dumps.

During mining, variations in material type, mine sequencing, area availability and emerging environmental factors can constrain the proposed final landform design. If during the design review process it is identified that the built waste dump cannot be converted to a safe and stable landform by land shaping (i.e. dozing) alone then additional management techniques may be employed.

The wrapping (when placed on the sides) and capping (when placed on the top) of waste dumps are being considered as part of the landform design at West Angelas when the largest proportion of the waste materials is comprised of less competent materials, where the waste dump footprint is constrained by tenure or other boundaries, necessitating the use of narrower berms in order to store the required waste volume during operations, and where rainfall runoff may be expected to flow onto waste dumps from the neighbouring catchment areas.

These techniques add a 1m deep layer of competent or rocky material to the outside of the landscaped waste dump. The material is blended into the surface using deep ripping techniques, before soil layers are applied. For the technique to be successful, berm widths in the initial waste dump design must be capable of supporting both the landscaping equipment and the competent material stockpiles after the initial landscaping of waste dump slope. A competent material stockpile of hydrated material has been proposed for Deposit E, to supply sufficient wrapping material to the waste dump. Further verification of the waste dump size, waste material characteristics and required stockpile volume will be resolved as part of the life of mine planning process in development for Deposit E.

Backfill and waste dumps located within mine voids are not proposed to be landscaped or vegetated.

**Table 14: Rehabilitation (final) landform designs.**

| Waste dump | Batter slope angle (degrees) | Lift height (m) | Berm width (m) | Back slope angle (degrees) | Comments |
|---|---|---|---|---|---|
| Deposit A North | 20 | 20 | 40 | 5 | |
| Deposit A West | 20 | 20 | 40 | 5 | Applies only to portion in contact with environment |
| Deposit A South | 20 | 10 / 15 / 20 | 20 / 30 / 40 | 5 | |
| Deposit B Western | 20 | 20 | 20 | 5 | Waste management will focus on dumping competent materials on the outer edge of the waste dump |
| Deposit B Eastern | 20 | 20 | 20 | 5 | |
| Deposit B Long term low grade | No rehabilitation design is available for this longer term stockpile. This material may produce a saleable product in the future, but is not currently included in the life of mine schedule for processing. | | | | |
| Deposit E East dump | 20 | 20 | 20 | 5 | Wrapping may be required |

## 16.2 Pit void and backfill management

Pit void management is undertaken in accordance with the Rio Tinto iron ore Guidance for Achieving Mine Void Closure. West Angelas has committed to backfill the mine voids to ensure no changes to groundwater quality occur as a consequence of evaporation.

Due to the nature of the groundwater systems and recent climate conditions, and accounting for local catchment runoff, groundwater is not expected to recover to the pre-mining water table. With this understanding, backfill levels for the West Angelas pit have been revised and recommended as listed inTable 15.

These levels are designed to prevent the creation of permanent lake systems at West Angelas, which could impact groundwater quality. It is recognized that, based on these recommendations, ephemeral lakes may form in the base of the pits as a result of incident rainfall and local runoff. Although the quality of the water within these ephemeral lakes may deteriorate as the water evaporates, the relatively minor salts resulting from these seasonal ponding events are not expected to alter groundwater quality over the long term.

**Table 15: Backfill levels recommended for West Angelas.**

| Pit | Backfill level (m AHD) |
|---|---|
| Deposit A CEPS | 630 |
| Deposit A CEPN | 620 |
| Deposit B B2 & B3 | 630 |
| Deposit B B1 | 620 |
| Deposit E | 650 |

These values will be reviewed and revised as further hydrogeological information and local pit geometry are resolved during the operating life.

### 16.3 Waterway design

The aim of drainage management at closure is to ensure the long term safety and the stability of engineered landforms, and to ensure local drainage is reinstated in such a way that impacts on local hydrology is limited. This includes ensuring surface flows are maintained, erosion and sedimentation of drainage channels is minimised and appropriate vegetation is returned where appropriate.

A Surface Water Management Plan has been developed for West Angelas as part of a greater Environmental Management Program. This Plan describes the interaction between natural surface water runoff, the local environment and the mine. It also describes specific water management strategies to be adopted on site to eliminate and/or mitigate any adverse impacts the operation may have on the surrounding hydrology.

Surface water management structures that have been or will be built to be retained on closure include:

- The diversion berm and drainage channel to the south of Deposit B to divert water from the western extents of the pit and waste dump areas;
- A diversion berm and drainage channel to the south of Deposit F used to divert minor surface water flows to the east, away from the deposits; and
- A diversion berm that will re-direct sheet flow from the south of A West to the west of the deposit.

At closure and as part of progressive rehabilitation design, physical design and construction of surface water management structures is guided by the Rio Tinto Environmental Design Principles for Permanent Facilities.

Key waterway design guidelines that are used to inform the design include:

- AUSTROADS (1994) Waterway Design: a Guide to the Hydraulic Design of Bridges, Culverts and Floodways.
- Institution of Engineers, Australia (2001) Australian Rainfall and Runoff, Editor-in-chief D.H. Pilgrim, Revised Edition 2001, Barton, ACT.
- Water and Rivers Commission (2000 onwards) Water Notes series, Water and Rivers Commission, Western Australia.
- Water and Rivers Commission (2003) River Restoration Manual, Water and Rivers Commission, Western Australia.

Drainage management designs will be based on surface water hydrology principles and practices relevant to the local climate, topography and material types. The majority of the final landform waterway designs will be undertaken as part of decommissioning activities and rehabilitation activities. Challenging aspects that will need to be considered include:

- Runoff from ridge lines onto waste dumps;
- Internal draining / sump locations used during operations to manage runoff; and
- Topographic low areas adjacent to the toe of rehabilitated waste dumps.

## 17. Contamination and hazardous materials management

The contaminated sites register maintained during operations records the location and details of any suspected or known contaminated areas. Used at closure, this inventory

identifies sites that require specific decontamination and the measures employed to achieve the required standard.

The primary sources of contamination at West Angelas that may require management at closure include:

- localised hydrocarbon spills;
- putrescible materials at landfill sites; and
- sewage irrigation area.

Fibrous waste materials excavated while mining are encapsulated in demarcated areas that are not expected to be disturbed as part of rehabilitation and decommissioning activities. No fibrous exposures have been identified in the pit walls of the closure landform.

Site closure will undoubtedly involve a change in land use, as such; the significance of any site contamination may change. A contaminated sites assessment will therefore be undertaken prior to closure, and specific plans developed, as part of the decommissioning process, to remove or manage contamination where appropriate.

# 18. Land and biodiversity management

## 18.1 Habitat planning

Mine related activities such as the clearing of native vegetation and soils, termination and modification of minor drainage flow paths and the introduction of new topographical features (waste dumps, tailing dam, mine voids etc.) can substantially change the habitat characteristics of the land. When substantial changes to soil, water or topography occur, in order to ensure a natural self-sustaining ecosystems after closure, alternate habitat types may need to be introduced or the pre-existing habitat types modified to accommodate the change(s).

As discussed in Table 10, characteristics of the plains, acacia woodlands, mulga woodlands, cracking clay and creek habitats maybe suitable for inclusion in the rehabilitation planning at West Angelas. Further work is required to define where within the closure landform these habitats characteristics may be utilised, to ensure the rehabilitation is sympathetic to the surrounding environment.

## 18.2 Rehabilitation

### 18.2.1 Soil management

During rehabilitation, it is assumed topsoil will be spread to a depth of 200mm over all disturbed areas and landforms created, excluding the mine voids, to assist with vegetation growth. As a consequence of the naturally shallow or rocky soil, topography, West Angelas will have a topsoil deficit. However, sufficient volumes of subsoil are predicted to be available to address the shortfall. Subsoil has physical properties suitable for plant growth and generally has chemical properties amenable to plant growth, although it does lack the high nutrient content, organic matter, soil seed back and mychorrihizal fungi properties of topsoil.

Top soil will be prioritised by:

- restricting topsoil application to use on less competent materials, where high quality vegetation growth is required to assist with landform stability; and
- reducing the thickness of soil spread across the site.

Where subsoil is required to be used instead of top soil the subsoil will be spread to a depth of 200mm.

### 18.2.2 Revegetation and seed management

Monitoring has shown that in small disturbed areas adjacent to existing vegetation or in areas where fresh topsoil can be utilised (e.g. borrow pits) appropriate species generally re-establish without the need for additional seed. This is because the seed bank in the fresh topsoil remains viable, resulting in good germination and growth, and in very small areas seeds can ingress from surrounding vegetation.

In most cases, however, locally collected seed is needed to assist in revegetation and the creation of a self-sustaining ecosystem. Over time the viability of seeds in stockpiled topsoil decreases, and thus the quality of the topsoil deteriorates. In addition the topsoil that was salvaged prior to disturbance may not contain seeds of all the target species of its new location / habitat.

Seed mixes for rehabilitation are preferentially of local provenance. Specific seed mixes are selected to provide a range of species appropriate to the desired habitat, taking into consideration landscape position and slope. In areas where erosion risks are identified, seed mixes may be modified to include or increase the portion of species that provide rapid cover.

Seed mixes may also include species of cultural significance to Traditional Owners, such as bush tucker and medicinal plants, if and when identified through ongoing consultation with Traditional Owners.

Rio Tinto Iron Ore purchases seeds on an annual basis from commercial seed suppliers, with emphasis on ensuring that there are appropriate local provenance seeds available for rehabilitation of each of its sites. Seeds are stored in a purpose-built facility at the Rio Tinto Iron Ore Dampier port facility, or off-site at facilities owned and managed by third parties.

## 18.3 Invasive species management

### 18.3.1 Weed management

An active weed management program is currently undertaken at West Angelas. This weed management program will be adapted for the closure landform, during the decommissioning study. The Weed Management Plan will define procedures to identify, control and eradicate target weeds and monitor weed control measures to minimise the spread of weed species, prevent the introduction of new weeds and control and/or eradicate both noxious and environmental weeds across the rehabilitated area.

Ten species of weeds have been identified to date at West Angelas that may require management on closure (Table 16).Weed eradication programmes will target weeds of high concern, while control measures will be used to manage all other weeds.

**Table 16: Weeds of West Angelas and surrounding areas**

| Scientific Name | Common Name | Priority Classification |
|---|---|---|
| Acetosa vesicaria (L.) A.Love | Ruby Dock | High |
| *Cenchrus setiger* Vahl | Birdwood Grass | High |
| *Cenchrus ciliaris* | Buffel grass | High |
| *Malvastrum americanum* | Spiked Malvastrum | Moderate |
| *Lactuca serriola* | Prickly Lettuce | Moderate |
| *Sigesbeckia orientalis* | Indian Weed | Moderate |
| *Sonchus oleraceus* | Common Sowthistle | Moderate |
| *Setaria verticillata* | Whorled Pigeon grass | Low |
| *Conyza bonariensis* | Flaxleaf Fleabane | Low |
| *Bidens bipinnata* | Beggars Tick | To be advised |

### 18.3.2 Feral animal management

Feral carnivores (e.g. cats, dogs, foxes) can create locally increased predation pressure on native fauna as well as increase competition with native species for resources such as space, water and food.

Feral herbivores (e.g. cattle, camels, donkeys) can also have a significant impact in Rangeland areas, such as the Pilbara. In dry times, grazing pressure reduces the abundance of palatable native species, impacting biodiversity and can create conditions

that encourage weeds to grow. Foot traffic impacts the soil conditions, and in combination with over grazing, can encourage erosion. Foot traffic has also been the cause of damage to cultural landmarks and Aboriginal sites. Overgrazing and damaged soils has a flow-on effect to native fauna species that rely on this vegetation for food and shelter.

Programs are in place to control feral animals during operations. Strategies for post-closure management will be developed as the site approaches closure.

# 19. Social factors

## 19.1 Cultural heritage management

The West Angelas Cultural Heritage Management Plan (CHMP) provides management strategies and procedures for the protection and conservation of cultural heritage at the site

The management plan is an important component of RTIO's commitments under the Cultural Heritage Management Regional Standard. The plan is designed to enable all Rio Tinto iron ore personnel and contractors to be confident that their work practices are sensitive to, and respectful of, the heritage values within the management area and the cultural values of the Traditional Owners. The plan is also designed to ensure RTIO complies with the *Aboriginal Heritage Act 1972,* Department of Aboriginal Affairs guidelines and Rio Tinto Cultural Heritage Standards.

Regular consultation is undertaken with Yinhawangka and Ngarlawangga peoples through (separate) Monitoring and Liaison Committee Meeting processes. This committee is a joint forum of Rio Tinto senior leaders and the Yinhawangka and (separately) the Ngarlawangga people, and is used to convey key information, undertake consultation and where required seek Traditional Owner feedback. The obligations to hold this meeting are clarified in the Commercial Agreements signed between Rio Tinto and the Yinhawangka people and the Ngarlawangga people.

The Monitoring and Liaison Committee includes closure as an agenda item when appropriate. The outcomes of these sessions inform the development of closure strategies, and are fully documented using the Cultural Heritage Management System.

Consultation will be sustained throughout the decommissioning and closure phases of the mine life to ensure cultural heritage is managed appropriately.

## 19.2 Local communities

Engagement with the community is undertaken through Rio Tinto Iron Ore's established processes and protocols for consultation. This process expands on the principles established by Rio Tinto's approach to Communities and Social Performance, guided by Rio Tinto's global code of conduct *The way we work*. Most closure consultation is conducted within this existing framework.

The area surrounding the mine is unallocated crown land with no homesteads or Aboriginal communities in close proximity and as a result, impacts on community receptors from nuisance dusts, noise and disturbance of visual amenity are expected to be limited, and therefore no specific management strategy is required.

There are other mining companies that hold mining leases adjacent to West Angelas (namely Fortescue Metals Group (FMG) and BHP Billiton Iron Ore), although no operations have been constructed to date. Management strategies will come into effect if / when these companies engage in mining operations in close proximity to West Angelas.

## 19.3 Workforce management

A Rio Tinto iron ore closure workforce management strategy is under development. This strategy will detail appropriate measures to provide alternative training or employment opportunities for West Angelas employees upon closure of the mine site. Where this is not practicable, the strategy will detail appropriate compensation measures. Specific

implementation plans for workforce management will be developed as the site approaches closure.

Closure is expected to occur over at least a two year period and a workforce will be required to complete the closure and decommissioning activities. A smaller workforce will be subsequently required to undertaken monitoring of the site as determined in the monitoring procedures developed during the decommissioning study.

Strategies for workforce management will be defined in greater detail over time and are not discussed further in this document.

# Stakeholder consultation

## 20. Stakeholder consultation

### 20.1 Key stakeholders

Key stakeholders with a potential interest in closure of West Angelas presently identified are listed in Table 17 below. This list is dynamic and is expected to evolve over time.

**Table 17: Key stakeholders**

| Category | Stakeholder |
|---|---|
| Federal Government | Department of the Environment |
| State Government | Department of State Development (DSD) |
| | Department of Aboriginal Affairs (DAA) |
| | Department of Mines and Petroleum (DMP) |
| | Environmental Protection Authority (EPA) |
| | Office of the EPA (OEPA) |
| | Department of Environmental Regulation (DER) |
| | Department of Parks and Wildlife (DPAW) |
| | Department of Water (DOW) |
| | Department of Regional Development and Lands (RDL) |
| | Department of Health (DoH) |
| | Department of Agriculture and Food WA (DAFWA) |
| | Main Roads WA |
| | Chamber of Commerce and Industry - Perth |
| | Pastoral Lands Board (PLB) |
| Local Government | Shire of East Pilbara |
| Non-Government | Weeli Wolli Co-management Board |
| | Wildflower Society |
| | Conversation Council WA |
| Community | Newman Community |
| | Yinhawangka |
| | Yamatji Marlpa Aboriginal Corporation (YMAC) |
| | Ngarlawangga |
| | Pilbara Aboriginal Business (PABs) |
| Internal | Rio Tinto employees and contractors |
| | Rio Tinto shareholders |

### 20.2 Stakeholder consultation process

Stakeholder consultation is undertaken to ensure all stakeholders have their interests considered during closure planning. Rio Tinto iron ore has established processes and protocols for consultation with each of its key stakeholders. This work expands on the principles established by Rio Tinto's approach to Communities and Social Performance, guided by Rio Tinto's global code of conduct *The Way We Work*. Most closure consultation is conducted within this existing framework.

Consultation is commenced in the early stages of the closure planning process, and continues through to site relinquishment. The consultation strategy used by Rio Tinto iron ore is designed to:

- identify stakeholders and interested parties;

- develop a targeted consultation plan to reflect the needs of the stakeholder groups and interested parties;
- integrate the consultation plan into the mine planning/closure planning process; and
- Where practicable, work with communities to manage the potential impacts of mine closure.

The focus for discussion on closure will change as the project matures. Examples of the focal areas for discussion are illustrated in Table 18.

**Table 18: Closure discussion framework**

| Stage | Discussion focus |
|---|---|
| Prior to the commencement of operations | Stakeholder identification and stakeholder mapping.<br>Commence closure-specific discussions with key stakeholders.<br>Agree key environmental, cultural and social values and closure objectives. |
| During operations | Ensure closure objectives and indicative closure criteria remain relevant and appropriate.<br>Communicate outcomes of studies undertaken to improve the closure knowledge base, reduce closure risks or improve closure strategies.<br>Communicate proposed changes to the closure plan. |
| In the lead up to closure (development of Decommissioning Plan) | Final completion criteria consensus.<br>Discussion future use of infrastructure post-closure.<br>Commence workforce communication strategy. |
| Post-closure | Process to meet commitments.<br>Progress against completion criteria. |

## 20.3 Communication register

Closure consultation is usually conducted within a broader Rio Tinto iron ore operation centric or regional consultation framework, as a component of Rio Tinto iron ore's on-going consultation forums.

- During mine expansion phases, closure consultation is conducted as part of the environmental approvals process to resolve closure objectives, issues and closure strategies. The environmental impact assessment process then provides any member with the public with the opportunity to comment on all aspects of the expansion, including closure.
- Consultation with Traditional Owners is regularly undertaken through the liaison forums, established under the terms of Indigenous Land Use Agreements with relevant groups.
- Consultation with State and Local Government stakeholders occurs as part of regular meetings held with individual agencies. Consultation on specific issues is also undertaken outside of these regular meetings as the need arises.
- Consultation with other stakeholders is conducted in a manner that is appropriate to the stakeholder and the specific issues requiring discussion.

Table 19 summarises topics that have been raised with or raised by stakeholders with respect to closure and the general opinion expressed.

**Table 19: Communication register**

| Stakeholders | Summary of discussion relevant to closure | Response |
|---|---|---|
| **Monitoring and liaison meetings** | | |
| 17 August 2006 | West Angelas development and closure plans | |
| Gobawarrah Minduarra Yinghawanga (GMY) | RTIO informed: future deposits (E, B, F, D, and Angelo) are planned. No plans for large scale dewatering or discharge of ground water. Long term plans are investigating backfilling the pits with waste as much as possible. Environmental approval process specifies: Protect the environment; Minimal clearing of the vegetation; Pits and waste dumps to back filled; Process to rehabilitate the ground. | Agreed GMY group to be involved in environmental plans |
| 21 May 2007 | Environment | |
| Gobawarrah Minduarra Yinghawanga (GMY) | GMY concerned about environmental impacts of West Angelas activities. GMY would like involvement in rehabilitation program | RTIO agree to present environmental aspects at next meeting (note: action was delayed until further in the future) |
| **Deposit E development proposal** | | |
| 5 September 2005 | | |
| CALM (Karratha regional offices) – Stephen van Leeuwin, Hayley Valentine and DoE – Owen Bennett, Ben Drew, Kate Barr | RTIO presented Deposit E proposal. | SvL advised: the mulga in the Deposit E area is significant, the more mulga we cover with waste dumps now the harder it will be to get future approvals. Try to minimise the footprint, particularly of the waste dumps – try to put waste back into pits or try to put waste round the corner of range areas (rather than on the flats where the mulga is located). Diversion of drainage through the valley will result in mulga present there dying. |
| **EPA Part IV** | | |
| January 1999 | Deposit A and B referral | |
| EPA Bulletin 924 | EPA advice provided for the Deposit A and B referral (relevant to closure) requested: location and design of waste dumps have no impact on vegetation with high conservation value or cracking clay areas; original drainage patterns be restored; and supports the commitment to pit infilling required to prevent evaporation of groundwater brought to the surface by capillary rise in the soil cover | Robe integrated advice into Decommissioning and rehabilitation plan. |

| Stakeholders | Summary of discussion relevant to closure | Response |
|---|---|---|
| 1 April 2010 | Deposit E closure plan | |
| EPA | RTIO submitted Preliminary Closure and Rehabilitation Management Plan developed for the Deposit E Operation | EPA advised: No EPA comments, Deposit E 'Not Assessed - Public Advice Given' on 4 August 2010. |
| 22 June 2011 | West Angelas Iron Ore Mine S46 MS 514 | |
| EPA | RTIO submission of a new Conceptual Closure Management Plan (part of the updated Environmental Management Program), prepared to support the Ministerial Statement Update. | EPA advised : No EPA comments, Section 45C Approval (Att 4) received on 30 January 2012. |
| 2 November 2011 | West Angelas Iron Ore Mine S46 MS 514 | |
| EPA | Discussion on West Angelas Ministerial Statement Update. | EPA proposed that a new Closure Condition would be imposed on the updated Ministerial Statement. |
| 31 October 2013 | West Angelas Iron Ore Mine S46 MS 514 | |
| Anthony Sutton, Director, Assessment and Compliance Division, Office of the EPA | Correspondence to RTIO: EPA proposing a condition on “Rehabilitation and Closure”, consistent with recent Ministerial Statements for other Rio IO Mines. As a result, the “West Angelas Operations Environmental Mgt Program” will need to be amended to remove Section 8.9 Closure and Rehabilitation Mgt Plan, so that there is no duplication between Condition 7 and the EMP. | RTIO complied with this request |
| 31 October 2013 | West Angelas Iron Ore Mine S46 MS 514 | |
| EPA | EPA provided West Angelas Ministerial Statement Update - Draft Conditions | - |
| 6 December 2013 | EPA Assessment No 1914 | |
| EPA | RTIO request rewording of Condition 8-4 to include provision for revisions of the Closure Plan (as per other recent Ministerial Statements).<br>Within 12 months of commissioning of the next mine pit or as otherwise agreed by the CEO the proponent shall implement the approved Mine Closure Plan and any subsequent approved revisions, and continue implementation until otherwise agreed by the CEO. | Recommendations were not carried through to MS 970. |

# Post-mining land use and closure objectives

## 21. Land use

### 21.1 Historical land use

As of the early 1990s, much of the area in the vicinity of West Angelas was zoned as vacant Crown Land. The good condition of vegetation at West Angelas has been attributed to small amount of historic cattle grazing, owing to the lack of water for cattle use. Pastoral activity in the region has historically been limited to grazing of cattle on Juna Downs Station to the north (the most southern boundary of which is located approximately 20 km to the north) and Rocklea Station (approximately 75 km to the west).

### 21.2 Options for post-mining land use

Options for post-mining land use are limited in the Pilbara region, with mining and pastoralism the only industries that have historically proven viable. Inland regions are sparsely populated, with the largest inland towns (such as Tom Price, Paraburdoo and Newman) established specifically to support the mining industry. Beneficial uses for the mining area (e.g. recreation or aquaculture) that might have potential in areas supported with a higher population base are unlikely to be viable.

Consequently, only two land use options have been identified that are potentially viable at West Angelas: establishment of a native ecosystem or pastoralism. As presented in Table 20, these options are mainly differentiated by the vegetation communities proposed to be returned on closure.

**Table 20: Potentially viable closure options identified for West Angelas.**

| Land use option | Differencing factors |
|---|---|
| Native ecosystem | Rehabilitate to maintain or foster regional biodiversity:<br>• Vegetation of local provenance species; and<br>• Revegetation planning considers establishment of multiple habitat types |
| Pastoralism | Rehabilitate to facilitate sustainable pastoral land use:<br>• Vegetation includes non-native species desired for rangeland cattle production;<br>• Infrastructure left in place to support pastoral activities. |

Until an alternate land use is agreed, the closure and rehabilitation strategy will focus on creating a safe, stable and non-polluting landscape vegetated with native vegetation of local provenance, to ensure the system remains compatible with general Pilbara land uses.

## 22. Closure objectives

### 22.1 Rio Tinto's vision for closure in the Pilbara

Closure objectives for West Angelas have been developed with consideration of Rio Tinto iron ore's general vision for closure of its Pilbara iron ore sites. Rio Tinto's vision for closure is to:

- Relinquish its mining leases to the Western Australian State Government;
- Preserve, protect and manage the cultural heritage values of the area in cooperation with the Traditional Owners and other stakeholders;
- Develop and implement strategies for closure which consider the implications on local communities;
- Achieve completion criteria which have been developed with stakeholders and agreed with Government;
- Develop landforms that are safe and stable and compatible with the surrounding environment and post-mining land use;
- Achieve environmental outcomes that are compatible with the surrounding environment;
- Implement a workforce strategy which addresses the impacts of closure on employees and contractors; and
- Achieve successful closure in a cost effective manner.

These vision statements reflect a broad range of closure issues relevant to all Rio Tinto operations in the Pilbara, and drive the development of strategies and plans for effective closure management.

## 22.2 West Angelas closure objectives

The ultimate goal of mine closure at West Angelas is to relinquish the site to the Government. This goal will be achieved once the government and community agree that the condition of the site is compatible with an agreed post-mining land use. Closure objectives reflect the aspects of the closure plan that the government and community agree are key to evaluating the site condition.

Table 21 lists the closure objectives identified for West Angelasduring the original public environmental review and engagement processes prior to the commencement of mining. The objective to “address public safety hazards” has been added to reflect Rio Tinto’s commitment to managing safety across the life of the operation. Objectives will be re-evaluated in future versions of the closure plan to ensure that they remain relevant and appropriate.

Completion criteria, described in Section 26, define how the successful execution of these objectives will be assessed to facilitate relinquishment.

**Table 21: West Angelas closure objectives**

| Number | Objective |
|---|---|
| 1 | Minimise the long term visual impact by reshaping the land so it is compatible with the adjacent landscapes. |
| 2 | Re-establish self-sustaining ecosystems. |
| 3 | Ensure no changes to groundwater quality through evaporation. |
| 4 | Address public safety hazards. |

# Post-closure landform

This chapter documents the outcomes that are expected to occur when the strategies for managing closure aspects documented in this closure plan have been implemented, assuming no changes to current mine plans.

## 23. Post-closure outcomes

Through the decommissioning and rehabilitation process, the post-mining landform is reshaped and vegetated to create the closure landform. When the wider environment and landscape is considered, including interactions with neighbouring hills and creeks, the area is referred to as the post-closure landform. The following sections provide a description of the anticipated post-closure landform following execution of the closure management activities.

### 23.1 Land

The shape of the landscape at West Angelas is still evolving, with the final mine void areas and waste dump locations and dimensions still in development across all of the deposits.

In the vicinity of Deposit A (Figure 11) the landforms will be similar to those currently established. The Deposit A pit will create a large void area, with unstable pit walls that will collapse into the void over time. The Deposit A south west waste dump will be rehabilitated and used form part of the abandonment bund for the Deposit A pit, providing a visual barrier to the unstable area around the edge of the mine void. The topography to the north, east and south west of Deposit A is too steep to successfully install an abandonment bund.

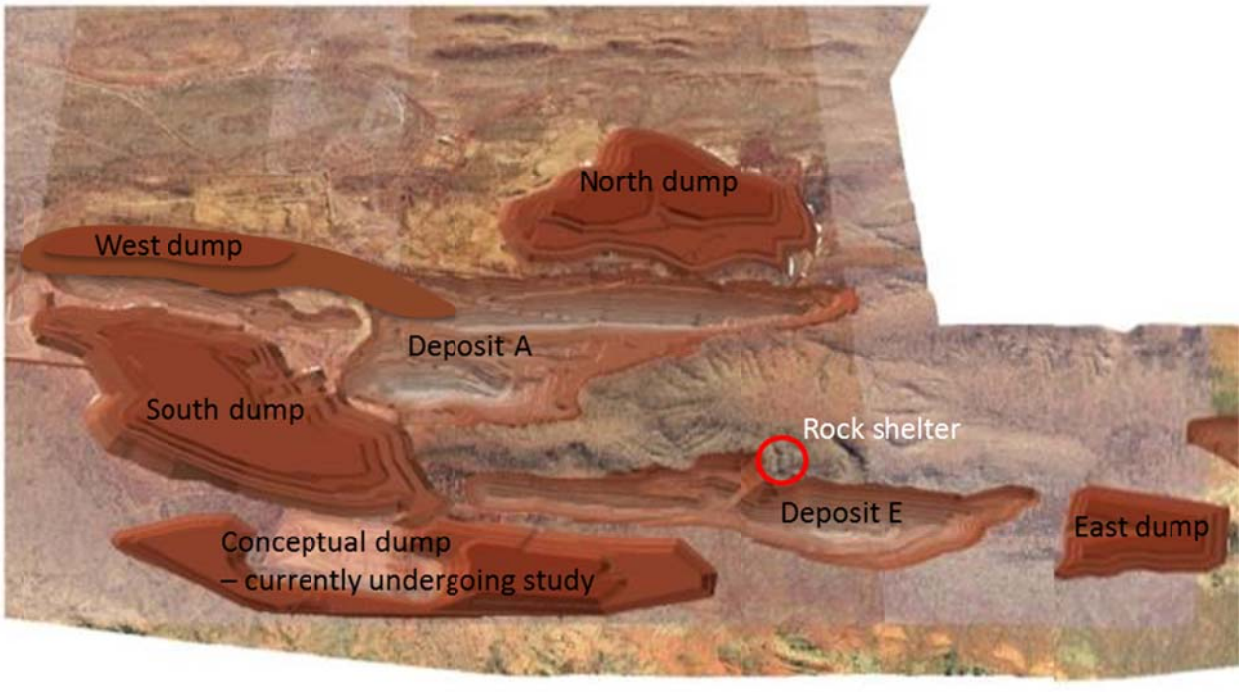


**Figure 11: Post-closure landscape looking over deposits A and E.**

At Deposit E, like Deposit A, the valley system that existed prior to mining will be completely transformed. The pit will create a large void area, with unstable pit walls that will collapse into the void over time. Preservation requirements for the rock shelter on the northern pit wall of Deposit E are under negotiation and will be resolved prior to closure. If the rock shelter is preserved, actions may be required to strengthen the wall, to ensure the site remains stable post-closure. An abandonment bund will be required along the southern and eastern edges of the pit, whereas the steep ridge to the north will provide a physical barrier in lieu of an abandonment bund.

The landform configurations for Deposits A West and F have yet to be defined. A concept sketch for Deposit F is presented in Figure 12, based on conceptual mining studies. The landforms through Deposit F will be similar to Deposit E, consisting of three satellite mine voids surrounded by rehabilitated waste dumps.

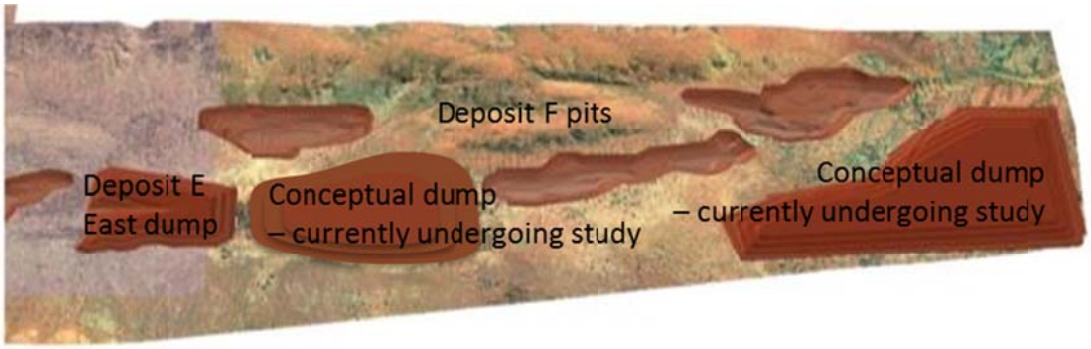


**Figure 12: Post-closure landscape looking over Deposit F**

A concept sketch for Deposit A West is presented in Figure 13, based on conceptual mining studies. The deposit is located in an area subject to overland flows. It is proposed that the diversion berm built to manage surface water flows for the mining phase would be retained at closure, to continue to the diversion of the flow to the west. Unlike other deposits at West Angelas, the crest of the Deposit A West mine voids are expected to be highly erodible and unstable due to the depth of alluvial material present around the pit crest. This is of particular concern due to the presence of downstream cracking clay ecosystems. A long abandonment bund is likely to be required around the entire perimeter of the mine voids.

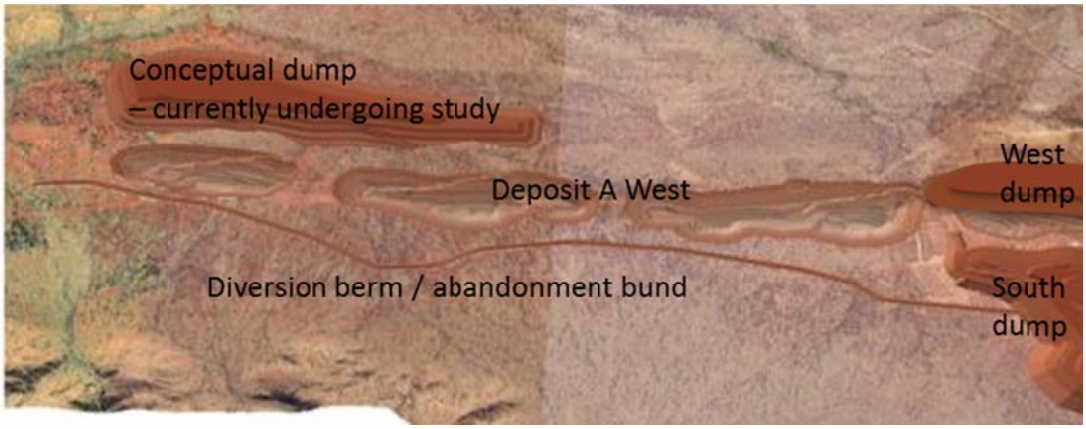


**Figure 13: Post-closure landscape looking over Deposit A West, immediately west of Deposit A.**

At Deposit B (Figure 14) the mine void is situated between two high ridge areas, flanking the void to the north and south. The Western waste dump almost closes off the valley, such that the valley mouth in the north western corner of the Deposit, immediately south of important Mulga vegetation communities, will be closed off with an abandonment bund.

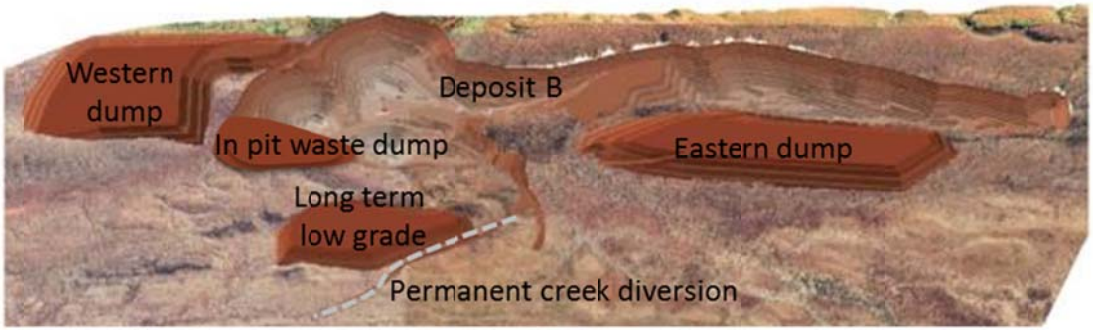


**Figure 14: Post-closure landscape looking over Deposit B**

## 23.2 Water

Local surface water hydrology has been substantially altered and redirected during the operating life of the mine. On closure, the landscape will be rehabilitated with consideration given to the changed topography and associated surface water flows that topography will generate. The original surface water flow paths will not be reinstated, and a new hydrological regime will be established across the disturbed areas of West Angelas. (It should be noted that these local alterations are not expected to significantly alter the hydrological regime beyond West Angelas compared to the conditions during mining.)

As mentioned, surface water control structures associated with Deposit A West, Deposit F and Deposit B are expected to be retained on closure and the areas surrounding the diversions rehabilitated to function as a natural drainage line.

It is expected that the groundwater levels in the pits will begin recovering immediately after cessation of mine dewatering, with water level rises slowing down gradually until equilibrium is reached between groundwater inflow, rainfall/runoff, groundwater outflow and evaporation. It is expected that the post-closure groundwater table will recover to a point below the pre-mining water table without affecting local and regional groundwater quality.

Following large rainfall events and prolonged (sequential) higher than average rainfall years, the formation of ephemeral pools within the mine voids are possible. It is expected that these pools will dissipate naturally during the following dry season.

## 23.3 Biodiversity

Revegetation will be undertaken across all disturbance areas and rehabilitated landforms other than within mine voids. Further resolution as the biodiversity outcomes for West Angelas will be presented once revegetation plans have been developed.

# Outstanding closure issues and knowledge gaps

This chapter documents outstanding issues to be addressed prior to closure in order to achieve appropriate outcomes.

## 24. Issues identification

### 24.1 Evaluation process

Rio Tinto iron ore has identified several aspects that require consideration when planning for closure of its Pilbara mining operations, including:

- Mineral waste (including PAF and fibrous materials);
- Pit lakes and ground water;
- Landform stability;
- Surface water impacts;
- Biodiversity;
- Visual impact;
- Cultural heritage;
- Local communities;
- Decontamination;
- Communication and consultation; and
- Other issues that may be relevant at a specific site.

A process for evaluating and managing issues has been developed which involves:

1) Identifying work that has been undertaken on each aspect, as it pertains specifically to the site in question. This may include baseline studies, stakeholder consultation, learning's from work undertaken at other sites, research and impact assessment studies. This review is used to identify any knowledge gaps;

2) Identifying the controls that are in place to manage each issue. This may include management plans / procedures, work practice guidelines etc. This review is used to identify any management gaps;

3) Reviewing the information in relation to identified gaps with a multidisciplinary team. This is undertaken to determine if the gaps are in the process of being closed, e.g. through on going knowledge development in line with the mine development, or if the gap constitutes a closure issue, requiring dedicated resources;

4) Establishing actions needed to resolve the issue, time to complete the task, and associated accountability;

5) Collating those actions into the Pilbara wide closure task register.

### 24.2 Issues list

The current status of closure issues for West Angelas are summarised in Table 22. Key issues are subsequently described in further detail.

Please note that the following categories have been applied based on the level of identified risk:

- **Managed** current management procedures controls and commitments are considered appropriate to allow stated closure objectives to be met.
- **Further investigations / discussions** the current level of knowledge is insufficient to determine whether closure objectives can be met, and will require specific investigations over and above current management procedures.

**Table 22 Summary of identified site issues assessment**

| Aspect | Current status | Conclusion |
|---|---|---|
| Landform stability | • Waste material is highly erodible and requires large footprint for waste dump to achieve stable design.<br>• Footprint for waste dumps constrained in some locations.<br>• Historic dumping practice may create additional challenges for cost-effective rehabilitation.<br>• Stability of pit wall below significant sites is uncertain and may require amelioration or mine design changes to accommodate closure requirements. | Further investigations |
| Biodiversity | • Post-closure landforms will not impact on functioning of communities.<br>• Opportunity to identify different habitat suitability of closure landform to guide species selection during rehabilitation. | Further investigations |
| Groundwater | • Closure strategy to prevent formation of permanent pit lakes by backfilling to groundwater recovery levels.<br>• Opportunity to investigate if permanent pit lakes would impact groundwater quality. | Further investigations & discussions |
| Cultural heritage | • Significant heritage sites located in and around site.<br>• Access to sites and repatriation requirements yet to be discussed. | Further discussions |
| Surface water | • Local surface water systems altered by mining operations won't be restored on closure.<br>• Surface water dependent ecosystems will not be further impacted by closure landform. | Managed |
| Mineral waste | • Geochemical characterisation of mineral indicates a low potential for AMD generation.<br>• Management plan in place to encapsulate fibrous materials when encountered. | Managed |
| Visual impact | • Potential for public access is limited | Managed |
| Contamination | • Standard management measures sufficient to manage contaminated areas | Managed |
| Decommissioning of infrastructure | • Demolition strategy with potential salvage current strategy<br>• Fixed assets unlikely to present potential complications to implementing current strategy | Managed |
| Other stakeholders | • Minimal impact to local communities due to proximity of site to population centres.<br>• Regulatory expectations for closure criteria untested. | Managed |

## 24.3 Key issues

### 24.3.1 Waste dump stability

A large proportion of the mineral waste at West Angelas is highly erodible. If the outer slopes of the dumps were to be composed of these highly erodible materials, the current waste dump designs would be costly to rehabilitate and new waste dumps designed to comply with the Landform Design Guidelines would require very large footprints.

Strategies have been developed for the Deposit A and Deposit B waste dumps to (theoretically) achieve a stable landform design. These activities include:

- minimising the amount of highly erodible material presenting on the outer waste dumps, through waste material separation and handling during operations;
- using in pit waste dumps where ever practicable; and
- utilising large berms on waste dumps, in accordance with the Landform Design Guidelines, to contain sediment and rainfall runoff, and prevent waste dump failure.

Part of the lowest lift of Deposit A south dump has been rehabilitated. Lessons learnt from the rehabilitation of this area will be used to inform future planning decisions.

The footprint available for establishing waste dumps at Deposit E is significantly constrained. The pit design for Deposit E has yet to be finalised, thus the percentage of highly erodible waste to competent material has yet to be determined. Current design assumptions suggest a stable landform will only be achieved by wrapping the outer dump in a layer of competent material. Stockpiles of competent material have been accommodated in the current design; however the implementation of such a treatment is unproven in the Pilbara.

Waste dump designs for Deposits A West and F are conceptual and will be reviewed and revised in line with future mining studies. Deposit A West is located close to the cracking clay community and has the potential to impact the community post-closure if a stable waste dump design is not achieved.

### 24.3.2 Pit slope stability

Sites of significant heritage and environmental value occur at several locations immediately above the pit walls. In general, the pit walls are not designed to be stable in perpetuity, and the pit walls are expected to collapse over time. This is especially true where a catchment exists above the pit wall, such that runoff from the catchment can also erode the pit crest even if the pit wall is geotechnically stable.

It is unclear if the sites of significant heritage and environmental value may be impacted by the collapse of the pit wall or erosion over the pit crest. Further work is required to verify the potential impact and develop appropriate mitigation strategies for locations that may be impacted.

### 24.3.3 Biodiversity in rehabilitation

West Angelas has a high level of biodiversity, with eight distinct habitats present in close proximity. Although the West Angelas development has removed some small parts of the habitats considered important, i.e. Mulga communities, there is the opportunity to review West Angelas' post-closure landform configuration to identify locations that may be rehabilitated to create a range of new habitats, with characteristics similar to those pre-disturbance habitats.

Further work will be undertaken to identify different habitat suitability within the closure landform. This information will be used to guide species selection during rehabilitation.

### 24.3.4 Groundwater quality

A pit backfill strategy has been adopted to prevent the formation of permanent pit lakes, to meet our obligation to ensure no changes to groundwater quality through evaporation. Backfill post-closure is costly, and an opportunity to reduce closure cost while continuing to achieve the closure objectives has been identified in terms of leaving pit lakes on closure.

It has been observed in other groundwater modelling studies that the creation of a pit lake that acts as a groundwater sink can have limited impact on the surrounding groundwater quality, as the salts are largely trapped within the lake. However, it is recognised that the creation of a pit lake can raise social concerns and have other environmental impacts.

Further investigations and discussions with stakeholders are required to determine if pit lakes can provide an acceptable closure alternative at West Angelas.

## 24.4 Research and investigation task list

Table 23 summarises the actions identified through the issues evaluation process.

**Table 23: West Angelas closure task list**

| Aspect | Reference | Task | Progress status |
|---|---|---|---|
| Objectives and criteria | - | Undertake stakeholder consultation to confirm that objectives, completion criteria and measurement tools are appropriate, and revise if required | Ongoing |
| Ongoing reviews and updates | - | Review data collected and information developed through the operation life. Use data / information to improve models, interpretations and verify predictions. | Ongoing |
| Closure landform | WA-01 | Develop and implement waste dump designs that appropriately mitigate erosion risks. | Ongoing |
| Closure landform | WA-02 | Geotechnically evaluate post-closure pit walls to assess long term stability in areas that may impact environmental or cultural heritage values (e.g. bat caves, culturally significant rock shelters) | Ongoing |
| Biodiversity | WA-03 | Identify appropriate locations for developing different habitat "types" to guide rehabilitation activities | Yet to start |
| Water | WA-04 | Investigate if the closure objective "to ensure no changes to groundwater quality" can be achieved in a more cost effective method than the current backfill approach.<br>1. is water quality of pit lakes acceptable<br>2. can pit wall stability issues be resolved (safe access to water, egress, caves)<br>3. can biodiversity implications be managed | Yet to start |

# Completion criteria

## 25. Completion criteria

### 25.1 Development process

Completion criteria are the checklist by which our stakeholders verify the site is presented in a condition suitable for relinquishment. Stakeholder feedback is sought during the mine life so that the completion criteria may be reviewed at each closure plan update, and may be refined accordingly. Stakeholder agreement on the completion criteria is negotiated as part of the Decommissioning Plan development (commencing at least five years prior to closure).

Rio Tinto Iron Ore recognises that the process of developing criteria needs to commence early in the planning process to enable baseline information to be collected, provide clear performance goals for progressive rehabilitation conducted during the mine's operational phase, and provide sufficient time for measurement methodologies and technologies to be developed, reviewed and agreed with stakeholders. Developing closure criteria early in the planning process also provides some contingency in the event of unplanned closure.

However, completion criteria finalised too early in the mine life may no longer be appropriate at the point of closure because:

- mine plan changes could have significant impacts on closure strategies and outcomes;
- the closure knowledge base can be expected to improve;
- stakeholders and stakeholder expectations may change; and
- environmental and social values, on both a local and regional level, may change (e.g. due to impacts of climate change, changes to post-mining land use etc.).

For these reasons, completion criteria need to be viewed as an evolving process, and criteria developed early in the mine life should be considered indicative only.

### 25.2 Indicative completion criteria

Table 24 lists the indicative completion criteria for each site closure objective[17]. These criteria are subject to ongoing review and update, and have yet to be extensively discussed with stakeholders.

To support the development and communication of the final completion criteria, indicative measurement processes and supporting data (evidence and/or metrics) lists are included in Table 24. The evidence and metrics column includes a range of information types that will be collected during the mine life or post-closure (as appropriate) and may be required to demonstrate, through the measurement process, that the completion criterion has been achieved.

The final, agreed completion criteria are expected to contain significantly greater detail than the indicative completion criteria.

[17] These objectives and completion criteria align with previous commitments made during the initial 1998 Mining Proposal for West Angelas, as reviewed by the EPA in Bulletin 924, and subsequently reported in the associated Decommissioning and Rehabilitation Management Plan (now superseded by this closure plan).

**Table 24: Indicative completion criteria**

| Objective | Indicative completion criteria | Indicative evidence / metrics that completion criteria have been met | Indicative process and/or monitoring methods |
|---|---|---|---|
| **Visual amenity and landform stability** | | | |
| Minimise the long term visual impact by reshaping the land so it is compatible with the adjacent landscapes | Erosion does not threaten the long term stability of the landform | Visual and measured assessment of erosion from rehabilitated areas for comparison of trends | Rill and gully frequency<br>Gully depth and width |
| | | Windrows used along the toe and crest of all slopes to prevent erosion | Conformance to the Landform Design Guidelines |
| **Biodiversity** | | | |
| Re-establish self-sustaining ecosystems | Vegetation overburden and topsoil has been re-used | Visual evidence that all top soil stockpiles have been used during rehabilitation | Maintenance of soil inventory |
| | Progressive rehabilitation has been carried out | Native, self-sustaining vegetation is present on previously disturbed land prior to final decommissioning activities | Vegetation monitoring including:<br>• Species richness<br>• Species diversity<br>• Percentage cover<br>• Weed count |
| | Vegetation on rehabilitated land is native and self-sustaining | Field vegetation monitoring for comparison of trends | |
| | Weed infestation is similar to that in nearby reference sites | Weed monitoring for comparison of trends | Environmental audits |
| **Water** | | | |
| Ensure no changes to groundwater quality through evaporation | Groundwater quality remains within the natural variability | Pit backfilled to predicted groundwater recovery level | Groundwater recovery modelling |
| | | Post-closure evaluation of water conditions against baseline (pre-mining) conditions and / or reference site trends over time. | Groundwater quality monitoring |
| **Public safety** | | | |
| Address public safety hazards | Measures to eliminate or mitigate public safety hazards have been agreed with stakeholders and have been implemented | Identification of potential hazards to the public in the decommissioned area.<br>Audit(s) to confirm that hazard mitigation measures have been implemented (e.g. removal of access roads to hill pits, abandonment bunds etc.). | Studies / reports:<br>• Geotechnical evaluation<br>• Fibrous materials audit<br>• Contaminated sites audit<br>• Electrical safety inspection<br>• Public access evaluation<br>• Traditional Owner cultural access requirements |

# Financial provision for closure

Rio Tinto considers specifics of the closure cost estimate to be commercially sensitive information. This section outlines the general processes used to develop the estimate.

## 26. Principles of Rio Tinto iron ore closure cost estimation

Closure cost estimates are determined based on methods outlined in the Rio Tinto Closure Standard and the Rio Tinto Accounting Policy. Two closure costs are developed for each site:

- A Present Closure Obligation (PCO) which is indicative of costs associated with closure of the mine given its current footprint; and
- A Total Projected Closure (TPC) cost which predicts the cost (in current terms) associated with closure at the end of the life of the mine. The TPC includes areas that are not currently approved, but that feature within the life of mine plan and that are considered likely to be developed in the future

The cost estimates consider the following components:

- Decommissioning (i.e. removal of infrastructure)[18];
- Final landform construction;
- Rehabilitation and biodiversity management;
- Heritage management;
- Workforce management (i.e. training costs and redundancy payments)[19];
- Monitoring costs;
- Costs associated with the development of a Final Decommissioning Plan;
- Costs associated with undertaking a final shutdown of operations;
- Allowance for failed rehabilitation or pollution that may necessitate rework of rehabilitation areas;
- Assignment of indirect costs in accordance with Rio Tinto Accounting Policy; and
- A contingency allowance.

## 27. Closure cost estimation methods

The amount recognised for closure at any given time will be determined by using the best and most recent estimate of the expected cost at that time. The closure cost estimation methodology is based on methods outlined in the Rio Tinto Closure Standard and Rio Tinto Accounting Policy, with the level of accuracy increasing as the site approaches closure.

The PCO estimate for each site is revised on an annual basis, whilst the TPC estimate is revised whenever a formal closure plan review is conducted. Note that for commercial reasons the actual estimate is not documented in this closure plan.

[18] The decommissioning cost estimate assumes that infrastructure will be demolished and buried on site. However; opportunities for salvage and recycling will be sought as the site approaches closure.

[19] Workforce management costs are only included in the TPC.

# Closure implementation

This chapter documents how closure for each site domain will be implemented.

## 28. Closure implementation

### 28.1 Closure domains

Closure domains are used to group areas with common features, rehabilitation and decommissioning requirements. Figure 15 illustrates the closure domains that have been established for West Angelas. These domains include:

- **Open pits**: Includes currently operating, developing or proposed pits associated with deposits A, A West, B, E and F, and areas where waste material has been backfilled into pits for which no rehabilitation is required or planned;
- **Waste dumps**: Includes inert external waste dumps and long term low grade material stockpiles that are not currently planned to be utilised in processing;
- **Landfill**: Refers to site landfill including general waste;
- **Borrow pits**: shallow pits created by the excavation of materials for construction purposes;
- **Disturbed areas – high**: Areas that will require significant earthworks to achieve final landforms, including ROM pad, product stockpile and surrounding areas, sealed light vehicle access roads, haul roads and rail loop;
- **Disturbed areas – moderate**: Areas that will require a moderate level earthworks to achieve final landforms including buildings (office and plant), airstrips, camp; and
- **Disturbed areas – low:** Areas that will require a low level of earthworks to achieve final landforms including laydown yards, unsealed roads and access tracks.

### 28.2 Implementation strategies and schedule

Implementation strategies that are unique to specific closure domains are presented in Table 25. The broader strategies for closure, previously been discussed in the *Closure management strategies sections 15 to 19*, will be used to inform the later development of the detailed plan, and consequently is not repeated below.

Refinement of the closure domains and associated detailed plans for the rehabilitation and decommissioning of these areas will be developed as rehabilitation areas become available or during the decommissioning study.

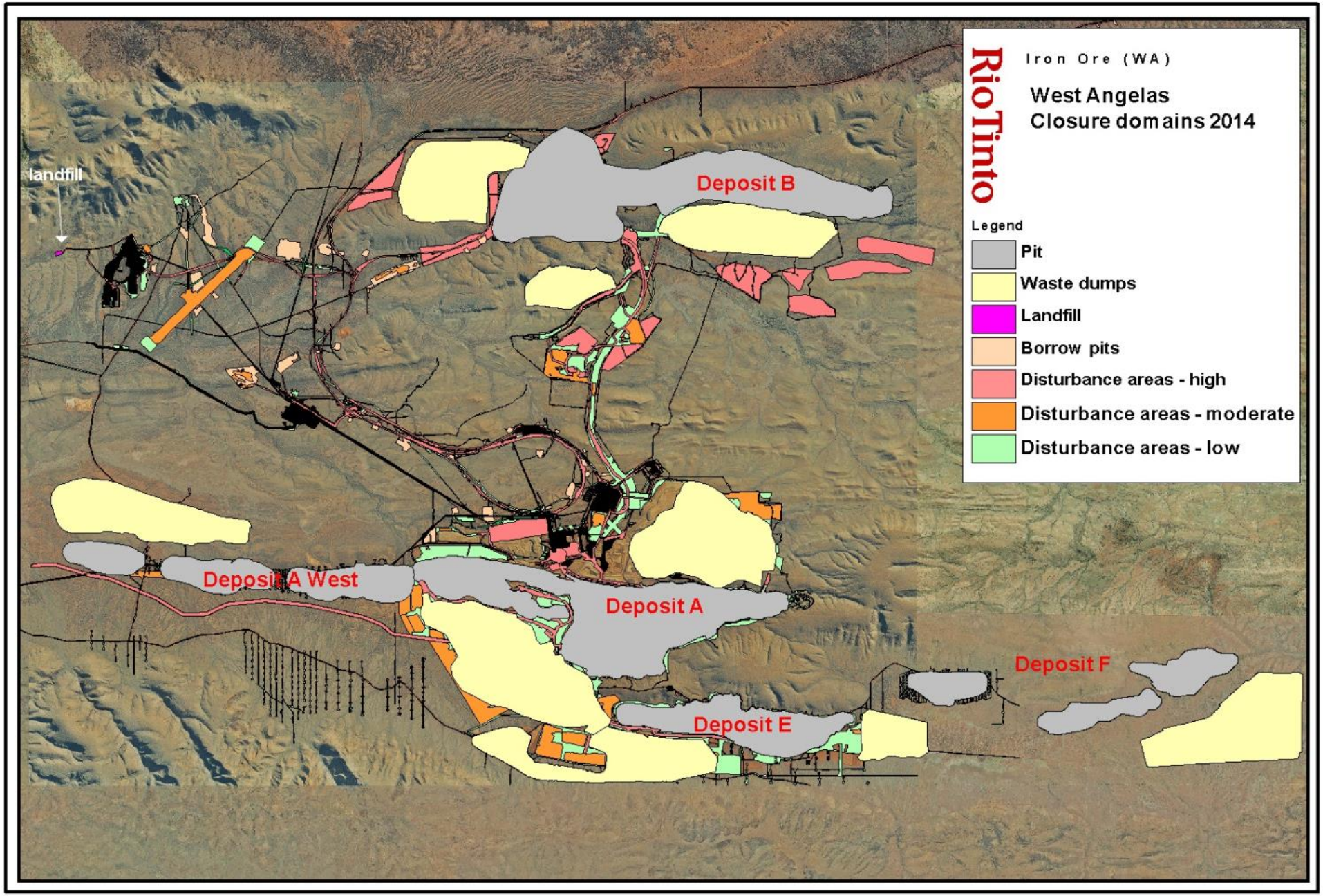


**Figure 15: West Angelas closure domains.**

**Table 25: West Angelas implementation strategies and schedule by domain**

| Domains | Area | Closure method | Indicative Closure Schedule |
|---|---|---|---|
| **Open pits** | All deposits and internal backfill areas | Backfill to the long term predicted groundwater recovery levels:<br>Deposit A CEPS to 630m AHD<br>Deposit A CEPN to 620m AHD<br>Deposit B B1 to 620m AHD<br>Deposit B B2 and B3 to 630m AHD<br>Deposit E to 650 m AHD<br>Deposit A West (multiple areas) levels yet to be resolved<br>Deposit F (multiple areas) levels yet to be resolved<br>Backfill not achieved during operations will be sourced from nearby waste.<br>Abandonment bunds are to be constructed around the perimeter of pit / pit clusters, where topography allows, outside of the zone of geotechnical instability. Waste dumps in close proximity to the pits may be used in place of sections of the abandonment bunds.<br>No rehabilitation treatment will be applied within the zone of geotechnical instability. | 2023 |
| **Waste dumps** | All external waste dumps and long term low grade stockpiles | Confirm material properties presenting on the face of the waste dumps and review design if characteristics are different from plan<br>Shape waste dump according to agreed waste dump design, in accordance with the Rio Tinto iron ore Landform Design Guidelines.<br>Topsoil will be spread over the dump surface where available to a depth of up to 0.2m and a deep rip and seed applied. | Under review |
| **Landfill** | Site landfill | Cap with at least 2m of competent inert material.<br>Re-spread topsoil windrows and stockpiled vegetation onto disturbed area. Shallow rip and seed. | 2023 |
| **Borrow Pits** | Borrow pits | Shape borrow pit to be self-draining.<br>Re-spread topsoil windrows and stockpiled vegetation onto disturbed area. Deep rip and seed if required. | 2023 |
| **Disturbed area - High** | ROM Pad<br>Product stockpile and surrounding area<br>Sealed LV access roads<br>Haul roads<br>Rail loop | Demolish or dismantle built structures to footing level. Remove bitumen and concrete. Dispose of demolition material to an appropriate waste site.<br>Undertake extensive earthworks and reshaping of areas to create a compatible landform consistent with the surrounding natural relief and landforms. Natural drainage lines to be re-established where practicable.<br>If the area is very compacted it may require preliminary ripping prior to topsoil, deep rip and seed treatment. | 2023 |

| Domains | Area | Closure method | Indicative Closure Schedule |
|---|---|---|---|
| **Disturbed area- Moderate** | Buildings (office and plant)<br>Airstrip (new)<br>Airstrip (exploration)<br>Main camp<br>Muir's camp<br>Topsoil stockpile areas<br>Fire training (and laydown) area | Demolish or dismantle built structures to footing level. Remove bitumen and concrete. Dispose of demolition material to an appropriate waste site.<br>Undertake earthworks and reshaping of areas to either return the area to natural relief or create a compatible landform consistent with the surrounding natural relief and landforms. Natural drainage lines to be re-established where practicable.<br>If the area is very compacted it may require preliminary ripping prior to topsoil, deep rip and seed treatment. | 2023 |
| **Disturbed area - Low** | Laydown yards<br>Unsealed roads and access tracks | Scatter any dead vegetation or rocks over the rehabilitated surface to increase habitat diversity and reduce wind and water erosion.<br>Natural drainage lines to be re-established where practicable.<br>Where top soil has not been removed and compaction is limited to two wheel tracks the area will be left to rehabilitate naturally. Other tracks should be ripped. On slopes, rip parallel to contours. | 2023 |

# Unexpected and/or temporary closure

## 29. Care and maintenance

In the event of temporary closure, measures will be undertaken to transfer the site from operations into a care and maintenance regime and relevant authorities notified. A Care and Maintenance Plan will be developed prior to the care and maintenance period which demonstrates how on-going environmental obligations associated with the site will continue to be met during the period of care and maintenance. Social obligations and responsibilities will also be addressed in this plan.

## 30. Unexpected closure

Whilst Rio Tinto considers the risk of unexpected closure to be minimal, there are numerous factors that could force early closure of one or several sites. Even if some level of contraction were to occur, it is reasonable to assume that Rio Tinto would continue to operate in the Pilbara and that it could continue to manage closure of its sites. It should be noted that the iron ore group is one group within the global Rio Tinto group of companies, which further mitigates this risk.

In the event of unplanned or sudden closure, Rio Tinto iron ore will notify all relevant authorities including the DMP. The existing closure plan for the site would then be revised and a Decommissioning Plan prepared and submitted to the DMP and other relevant authorities within three months of notification of closure. The Decommissioning Plan will include undertaking detailed consultation with stakeholders. Once the plan is approved by the relevant authorities, work will commence on closure implementation activities.

# Closure monitoring and maintenance

## 31. Closure monitoring programs

### 31.1 Monitoring phases

An extensive environmental monitoring program is underway at West Angelas to track the performance of the operation, identify potential environmental impacts and to better understand the environment surrounding the mine in order to avoid or minimise future environmental impacts. This includes:

- Baseline monitoring, which is conducted as operations expand into new mining areas; and
- Operational monitoring, which occurs throughout the life of the mine, in line with regulatory requirements and the Rio Tinto operational standards.

Results from the operational environmental monitoring program that are relevant to closure are summarised in the *Collection and analysis of closure data* Sections 10 to 14.

A phased approach to closure monitoring, consistent with other Rio Tinto iron ore sites, is proposed for West Angelas:

- Pre-closure monitoring: occurs as the site approaches closure to establish post-mining baseline conditions (where required). Aspects that may need to be collected to establish the post-mining conditions include water levels outside the active mine area, riparian vegetation condition, and potentially terrestrial fauna;
- Decommissioning monitoring: conducted during the period of active site decommissioning and rehabilitation. This monitoring plan will be developed as part of the Decommissioning Plan, to ensure the activities do not adversely impact the environment; and
- Post-closure monitoring: conducted on a scheduled basis until the completion criteria have been met. This monitoring plan will be developed as part of the Decommissioning Plan.

The monitoring aspects expected to be undertaken at each phase of monitoring are listed in Table 26. It is expected that the monitoring programs will be sufficiently flexible to enable adjustments to be made if results indicate that more or less monitoring is warranted at any particular phase.

**Table 26: Indicative closure monitoring schedule**

| Monitoring aspect | Phase | | |
|---|---|---|---|
| | Pre closure | Decommissioning | Post closure |
| Erosion # | ✓ | ✓ | ✓ |
| Vegetation (rehabilitation) # | ✓ | ✓ | ✓ |
| Weeds # | ✓ | ✓ | ✓ |
| Fauna # | ✓ | ✓ | ✓ |
| Ecology function | ✓ | | ✓ |
| Contaminated sites assessment | ✓ | ✓ | |
| Water quality | ✓ | ✓ | ✓ |
| Hydrology and hydrogeology | ✓ | | |
| Heritage | ✓ | ✓ | |

# These monitoring activities also part of the Rio Tinto Iron Ore Rehabilitation Monitoring Procedure.

### 31.2 Rehabilitation monitoring

Rehabilitation monitoring tracks the progress and evaluates successional development of rehabilitation areas. This information is used to assess progress towards long term rehabilitation objectives and to improve rehabilitation techniques.

The Rio Tinto Iron Ore Rehabilitation Monitoring Procedure details the monitoring methodology for recording and assessing vegetation development, fauna re-colonisation / habitat development and erosion. The procedure also ensures monitoring is carried out in a safe, efficient manner across all Rio Tinto Iron Ore Pilbara operations.

Habitat characteristics are recorded by quadrat at intervals along transects at established in rehabilitation and associated reference sites. Qualitative assessment of erosion, soil surface, perennial vegetation cover, species richness, weeds and general condition is also recorded.

The current monitoring programme includes:
- number of plants by species;
- percentage cover by species;
- bare areas in quadrat;
- percentage of perennial cover;
- percentage of spinifex cover;
- percentage of grass cover (excluding spinifex);
- percentage of native perennial shrub cover (0.5m to 2m);
- percentage of litter cover;
- percentage of tree cover >2m;
- presence of annuals; and
- presence of weeds, and species.

Transects are also reviewed as a whole to record:
- number of logs (>10cm diameter and >30cm long);
- number of rocks (>15cm diameter);
- presence of scat;
- presence of ants,;
- general animal sighting (including tracks, burrows and nests);
- flowering and fruiting species;
- extent of grazing; and
- if burnt since last monitoring.

Monitoring of rehabilitation and reference sites is scheduled annually for the first three years after establishment, biennially from years five to nine and (approximately) triennially thereafter, until the completion criteria is achieved.

Analysis of the trends observed at rehabilitation sites over time and in comparison to reference sites is being studied to develop an understanding of rehabilitation quality and successional processes in our rehabilitation.

## 31.3 Erosion monitoring

The Rio Tinto procedure for erosion monitoring is detailed in the Rehabilitation Monitoring Procedure.

Monitoring involves the examination of transects for the number of rills and gullies, recording their width and depth. These measurements are compared over time to determine if the landform has stabilised; for example erosion rates are within the accepted completion criteria range or rill and gully geometry is similar to the surrounding landscape. If a landform fails to stabilise, further management / intervention will be applied.

## 31.4 Weed monitoring

During the pre-closure and decommissioning phases, weed management activities will be undertaken in accordance with the weed management program. This program includes targeted weed inspections and controls undertaken annually and following significant rainfall events. Weed hygiene activities will also be employed for vehicle and earthmoving machines to minimise the distribution of weeds.

During the post-closure phase weed monitoring will be undertaken as part of the rehabilitation monitoring activities.

# Management of information and data

The retention and accessibility of multi-disciplinary mine records, is vital to successful mine closure and rehabilitation. This section provides an overview of the information management systems used by Rio Tinto iron ore, in order to manage closure related data.

## 32. Data and information management

### 32.1 Iron Ore Document Management System (IODMS)

Rio Tinto iron ore operates a comprehensive document management system, with electronic records of all key information and data. The document system, known as Iron Ore Document Management System (IODMS) is linked to other business units within the Rio Tinto group of companies, and processes are in place to ensure that the data contained within this system is appropriately backed up and protected. Each document stored within this system is given a unique document number which identifies the document and enables it to be accessed. This system will continue to operate following site closure, and all relevant data will be retained accordingly.

An audit will be conducted prior to closure to ascertain whether there is any additional information stored in hard copy form at the site. Such data will be scanned and entered into IODMS to ensure that it is appropriately retained post-closure.

Hard copies of confidential information stored at the site (such as employee records) will be destroyed at the time of closure.

### 32.2 Closure knowledge base

The closure knowledge database is a new knowledge management process designed to bring closure related research and monitoring outcomes together into one searchable location.

The closure knowledge database uses a single entry form to capture the key characteristics of all new ongoing and completed closure related studies. The same form is used to inform the closure team that work has commenced, to provide progress updates and to report on the outcomes of the work.

Key characteristics provided include where the report is stored and where the research can be applied. This information is then managed by the Closure team within a secure database.

Reports generated from the database will be used to track research projects, communicate closure obligations and automate compilation of information used in our closure planning.

### 32.3 EnviroSys

EnviroSys is a desktop application, with a web based interface, that manages environmental and hydrogeological parameters collected in the field and their logical context. The tool is used to store, monitor and analyse those parameters and report trends on data collections.

Data collected includes:

- groundwater – biological, chemical, field, levels, production;
- marine water – biological, chemical, field;
- soil chemistry;
- surface water – biological, chemical, field, levels, production;
- tonnes and moisture;

- water meters; and
- weather (rainfall, temperatures etc.).

EnviroSys is used across all WA Rio Tinto iron ore sites. Its application is necessary to support the building of closure knowledge bases, as well as ensure compliance with internal Rio Tinto standards and operating licenses pertaining to data management.

## 32.4 Legal and other requirements system

The Legal and Other Requirements System (LAORS) is used by Rio Tinto iron ore to manage the following:

- Approval and Legislation Reports which provide a high level snapshot of approvals and legislation and is used to check the status and expiry dates of approvals.
- Approval and Legislative Requirements Reports which lists
  - accountabilities for specific conditions within approvals and clauses within legislation;
  - required actions to comply with approvals and or legislation; and
  - due dates for specific requirements.
- Statutory Position Appointed Persons reports which list individuals appointed to a statutory position.
- Statutory Position Accountabilities Reports which identify clauses of legislation that the statutory position is accountable for.

A LAORS register detailing key closure obligations applicable to West Angelas is provided in Appendix A.

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# Appendix A – Register of key closure obligations

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Advice

# General closure obligations

10 September 2013

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# General closure obligations

**Scope**

This document outlines the general obligations relating to mine closure that arise under legislation and common law (**General Obligations**).

It is intended that this document be read in conjunction with any review of the specific closure requirements that apply to each particular Rio Tinto Iron Ore (**RTIO**) operation (ie under State agreements, approvals, licences and other commitments).

**Key issues**

The main sources of General Obligations relating to the closure of RTIO's sites arise from:

- *Guidelines for Preparing Mine Closure Plans*, published jointly by the Department of Mines and Petroleum (**DMP**) and the Environmental Protection Authority (**EPA**) (the **Guidelines**);
- environmental licensing and pollution control provisions under Part V of the *Environmental Protection Act 1986* (WA);
- obligations and approvals under the State Agreements to which RTIO is a party;
- obligations and approvals under the *Environmental Protection (Controlled Waste) Regulations 2004* (WA);
- obligations and offences under the *Environmental Protection (Unauthorised Discharges) Regulations 2004* (WA);
- obligations and offences under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth);
- obligations arising under the *Contaminated Sites Act 2003* (WA);
- requirements imposed by the *Mining Act 1978* (WA) (**Mining Act**) and the *Mining Regulations 1981* (WA);
- obligations imposed by the *Mines Safety and Inspection Act 1994* (WA) and *Mines Safety and Inspection Regulations 1995* (WA);
- offences created under the *Criminal Code Compilation Act 1913* (WA);
- standards set by ISO 14001:2004; and

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- common law liability arising from:
  - nuisance;
  - negligence;
  - breach of statutory duty; and
  - standards of reasonableness and the relevance of guidelines and codes of practice.
- agreements arising from negotiations with Traditional Owners; and
- obligations arising from joint venture arrangements.

This review also comments on:

- the Rio Tinto Closure Standard (V4.0 2012); and
- future legal developments that may affect closure standards.

**Recommendations**

We note that this document relates only to the General Obligations as at 10 September 2013. Environmental law is a rapidly developing area of law. This advice should be reviewed and updated every 5 years initially, with more frequent reviews occurring closer to the time of closure for a particular RTIO site.

We also note that this document relates only to a long term plan for site closure.

We recommend that RTIO consider planning for a forced, rapid closure scenario to ensure legal risks in that instance are appropriately managed.

Further, we recommend that RTIO review the specific obligations and closure plans in respect of each particular RTIO operation.

This document does not cover RTIO's contractual relations with contractors and other third parties. If it does not already do so, RTIO should have a process for dealing with those relations in a closure scenario.

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# Detailed advice

## 1 General commentary – managing different types of legal risk

In considering the General Obligations for closure outlined in this document, it is important to be aware of the nature of the obligation imposed on RTIO.

The process of identifying the nature of the obligation imposed on RTIO will enable RTIO to:

- eliminate the legal risks that can be eliminated; and
- properly manage the legal risks that cannot be eliminated,

when planning for closure (eg take practical steps to relinquish or minimise particular legal risks to the extent they can be).

### 1.1 Risk categorisation under the Environmental Protection Act

RTIO's most serious potential environmental liabilities arise under the *Environmental Protection Act 1986* (WA) (**EP Act**) and associated regulations. These liabilities also include a range of potential offences (see discussion in parts 3 and 5 of this document).

Offences under the EP Act can relevantly be categorised on the basis of whether they apply to:

(a) the occupier of the relevant premises;

(b) 'any person'; or

(c) the holder of a licence, works approval or other authorisation.

### 1.2 'Occupiers' and 'holders of a licence, works approval or other authorisation'

In relation to category (a) and (c) risks, there are some basic steps that RTIO can take to eliminate (or at least reduce) its risk exposure.

For offences which apply to the occupier of the relevant premises, only the occupier may be prosecuted. Section 3 of the EP Act provides that 'occupier', in relation to:

(a) any premises: means a person who is in occupation or control of those premises, whether or not that person is the owner of those premises; or

(b) premises different parts of which are occupied by different persons: means, in relation to any such part, a person who is in occupation or control of that part, whether or not that person is the owner of that part.

Examples of occupier offences include the duty on occupiers to take certain measures under section 51 of the EP Act (see discussion in part 4.10 of this document). In relation to this category of liability, it is possible for RTIO to take steps to eliminate (or at least reduce) its potential liability by ceasing to occupy the premises.

Similarly, in relation to the holder of a works approval, licence or other authorisation, it is possible for RTIO to take steps to eliminate (or at least reduce) its potential liability by relinquishing the relevant authorisation.

Acts as occupier or the holder of an authority are crystallised on expiry of occupation or the authority and there is no risk following that expiry that these offences can be committed. However, a risk remains that a prosecution will be instituted for an offence caused by acts prior to the expiry, subject to the relevant limitation periods (considered in part 4.2 below).

### 1.3 'Any person' offences

By comparison, in relation to 'any person' liabilities RTIO cannot simply relinquish its risk exposure.

These liabilities attach to the person (which includes a company), and do not extinguish upon ceasing to occupy a premises or the relinquishment of the authorisation.

### 1.4 Application of risk categorisation to this report

To assist RTIO in the identification and management of different legal risks, we have categorised each of the different liabilities under the identified legislation as:

- extinguishable liability (eg upon ceasing to occupy the premises or upon relinquishment of the licence etc); or
- ongoing liability (ie in the case of 'personal' offences).

## 2 Extent of RTIO liability

The extent of RTIO's legal liability under legislation or common law will often rest on what constitutes an acceptable standard of performance. Legally, the determination of what is acceptable is influenced by current industry and community standards. Such standards vary with the advent of new methods and technology ('best practice') and with changing views of justice or loss shifting. This is particularly so for environmental issues where the community shows increasing levels of concern about pollution and contaminated land.

In the case of legal liability for mine closure, a key issue will be whether in closing its operations RTIO has taken reasonable steps to safeguard against causing environmental impact. In determining what is reasonable in the circumstances of a particular case, where required to do so courts will take into account the state of knowledge for a range of matters such as technology and standards of performance in management at the time the operation was closed.

A closure plan must be able to adapt to shifting industry and community standards. The extent to which RTIO complies with relevant guidelines and codes of practice, prepared by regulators or the mining industry, will be relevant in determining legal liability where it is necessary to judge an acceptable standard of performance. While compliance with such standards is likely to be a key factor in establishing whether RTIO's closure practices are acceptable, the courts have made it clear that such standards should not be considered an authoritative guide for determining liability. Nevertheless, adherence to guidelines and codes of practice is important in establishing the defence of due diligence or refuting an allegation of negligence.

Completion criteria developed by RTIO in consultation with key stakeholders will form the basis on which mine closure performance is measured and reported to government, and will determine when a site is assessed as suitable for relinquishment.

We are instructed that RTIO prepares indicative criteria at the project approval stage, with the intent that these will evolve over the life of mine and be finalised as the site

approaches closure. RTIO endeavours to finalise and agree completion criteria with stakeholders when preparing decommissioning plans (that is, 5 years before scheduled closure).

The Guidelines state that:

- Development of completion criteria should commence either during the project approval stage for new projects, or as early as possible for existing projects, and will be reviewed and refined throughout the development and operation of the project.
- Indicative completion criteria may be acceptable at the project approval stage, provided that they are capable of objective verification and based on the best available data at the time. As the project progresses and more information becomes available, more comprehensive and detailed completion criteria should be developed.

The closer a project is to completion the more certain the regulator will expect the completion criteria to be. There is no clear obligation imposed under the legislation of the Guidelines. However, it will be increasingly difficult for RTIO to explain unknowns or gaps in completion criteria as a project approaches the point of decommissioning. The section below provides further details on the obligations under the Guidelines.

# 3 Guidelines for Preparing Mine Closure Plans

## 3.1 Background

From 1 July 2011, all new RTIO mining proposals, in respect of new or existing mine sites, submitted to the DMP under the Mining Act, are required to include a Mine Closure Plan (**MCP**) which is to:

- be in the form required by the guidelines approved by the Director General of Mines for the purposes of the Mining Act; and
- contain information of the kind required by these guidelines about the decommissioning of each proposed mine, and the rehabilitation of the land, in respect of which a mining lease is sought or granted, as the case requires.

Further to this, the DMP has stated that it will require all existing RTIO mining proposals to prepare a MCP in this form by 30 June 2014.

Following the publication of the June 2011 Guidelines, a frequently asked questions document entitled 'Administration of Mine Closure Plans' (**FAQ Document**) was released by the DMP. The purpose of the Guidelines is to ensure that a planning process is in place so mines can be closed, decommissioned and rehabilitated in an ecologically sustainable manner, consistent with agreed post-mining outcomes and without unacceptable liability resting with the State.

Although described as Guidelines, section 70O of the Mining Act defines 'mine closure plan' to mean a document that-

(a) is in the form required by the guidelines; and

(b) contains information of the kind required by the guidelines.

In this regard, the Guidelines establish minimum industry standards for closure and are more akin to a standard.

## 3.2 Applicability and time-frame

MCPs are required for all new RTIO mining proposals submitted to the DMP under the Mining Act.

For all RTIO mining proposals that are not subject to the Mining Act (ie pre-1899 title or minerals-to-owner tenure, Hampton locations or State Agreement Act projects), RTIO may be required to submit an MCP to the EPA as part of the Part IV Environmental Impact Assessment process.

The vast majority of mining proposals submitted by RTIO are submitted under State Agreements with very few mining proposals being submitted to the DMP under the Mining Act. Therefore, RTIO is usually only required to submit mining proposals to the DMP for ancillary support infrastructure where that infrastructure sits on Mining Act tenure and there is a condition on that tenure requiring the submission of a mining proposal to DMP. The DMP has verbally indicated that it will not require full closure plans for such infrastructure, and to date has considered the brief closure strategies submitted by RTIO with these proposals to be sufficient. However this position has no legislative basis and more comprehensive closure plans may be required in the future once priority sites have approved closure plans in place.

RTIO should note that the DMP has stated that the Guidelines will apply to projects under specific extractive licenses (including RTIO's State Agreements). However, in our view there is no legislative authority for this.

DMP has stated that existing mining operations that have a proposal or Notice of Intent approved by the DMP prior to 1 July 2011 will be required to submit a MCP to the DMP by 30 June 2014. Also, existing mining operations will be required to submit a new MCP if they significantly alter the nature of the operations.

The DMP is in the process of sending letters to all existing mining project operators specifying individual deadlines for the completion of MCPs and imposing tenement conditions to this effect. The DMP has stated that it will require MCPs to be submitted to DMP for all existing sites by 30 June 2014. Projects will be prioritised depending on prior closure planning, the lifespan of the mine, rehabilitation liability and the level of public interest.

MCPs submitted with mining proposals should be approved within 30 business days (the current timeframe for approval of mining proposals). However, DMP has stated that it plans to trial 60 business day approval timeframes for new MCPs.

If DMP considers that a MCP does not meet the standards specified in the Guidelines the FAQ Document states that the tenement holder will be given two formal opportunities to address any deficiencies and if, in the opinion of the Assessing Officer, the MCP remains deficient, then they will make a recommendation to the Regional Minerals Manager to reject the MCP.

## 3.3 Preparation of MCPs

Planning for mine closure should be fully integrated in the life of mine planning, and should start as early as possible and continue through to final closure and relinquishment. For new projects, closure planning should start in the project feasibility stage (before project approvals).

RTIO's MCPs must be site-specific. Generic 'off-the-shelf' closure plans will not be accepted by the DMP or the EPA.

## 3.4 Structure of MCPs

RTIO's MCPs must identify post-mining land use options and set out site-specific closure objectives that are consistent with those land use options. A MCP must also include completion criteria, to provide the basis on which successful rehabilitation and mine closure is determined. According to the Guidelines, the structure of RTIO's MCPs should be as follows, unless an alternative format has been agreed to in writing by the DMP or EPA:

- Cover Page;
- Checklist;
- Table of Contents;
- Scope and Purpose;
- Project Summary;
- Identification of Closure Obligations and Commitments;
- Collection and Analysis of Closure Data;
- Stakeholder Consultation;
- Post-mining Land Use(s) and Closure Objectives;
- Identification and Management of Closure Issues;
- Development of Completion Criteria;
- Financial Provisioning for Closure;
- Closure Implementation;
- Closure Monitoring and Maintenance; and
- Management of Information and Data.

## 3.5 Risk-based principle

RTIO's MCPs must be prepared in accordance with a risk-based approach to mine closure. This means that the level of detail required by the DMP and EPA will increase as environmental risk increases.

A risk-based approach to RTIO's MCP preparation will require a consideration of material characterisation, data on the local environmental and climatic conditions, and consideration of potential impacts through contaminant pathways and environmental receptors.

Characterisation of materials needs to be carried out prior to project approval to a sufficient level of detail to develop a workable MCP. For existing operations, this work should start as soon as possible. Characterisation of materials should include the identification of materials with potential to adversely affect the environment.

## 3.6 Adaptive management principle

RTIO's MCPs must also be prepared in accordance with principles of adaptive management. This is important in case of temporary or sudden mine closure. MCPs must demonstrate that appropriate systems for monitoring, maintenance and record keeping are in place.

### 3.7 Consultation in preparation of MCPs

Consultation must take place between RTIO and stakeholders. This must include acknowledging and responding to stakeholder's concerns.

Post-mining land uses should be identified and agreed upon through consultation before approval of new projects. This should take into account the operational life span of the project, opportunities to improve management outcomes of the wider environmental setting and landscape, as well as possibilities for multiple land uses.

For existing mining projects, post-mining land uses should be agreed as soon as practicable.

### 3.8 Change and review of MCPs

Any substantial change to RTIO's MCPs regulated under the Mining Act will require a new Mining Proposal to be submitted to DMP for approval. The Mining Proposal will be subject to the same approval requirements as those for a new mining operation or project. If the new Mining Proposal constitutes changes to a proposal approved under Part IV of the EP Act, the changes must also be approved in accordance with processes and procedures under that Act.

RTIO's MCPs regulated under the Mining Act will be required to be reviewed every three years, or any other time period stipulated by the DMP. In respect of MCPs prepared for the purposes of Part IV of the EPA, requirements for review and the associating time period may be stipulated in the conditions attached to the approval. Where the conditions do not stipulate a requirement for review RTIO is under no obligation to review the MCP.

RTIO's MCPs will be available for public scrutiny once approval has been given by the DMP.

### 3.9 Mining bonds

At this stage, cost estimates conducted for the purpose of demonstrating financial provisioning for MCPs are not intended to be applied in the calculation of mining securities. However, we note that mining securities are not required for State Agreement sites, and bonded sites are proposed to transition to the Mining Rehabilitation Fund scheme by July 2014.

The financial provisioning requirements in MCPs are for tenement holders to demonstrate that they will have funds available in the future to address their financial obligations for mine rehabilitation.

### 3.10 Legal Obligations Register

One of the implications of MCPs is the preparation of Legal Obligations Registers. Relevant legal obligations need to be identified and a Register created in a suitable form.

## 4 Environmental Protection Act

### 4.1 Background

Outlined below are the obligations for closure which arise under the EP Act.

Part IV of the EP Act relates to the environmental assessment of proposals and subsequent approval by the Minister for the Environment (**Minister**). The Minister may place certain conditions on an approval that may affect closure operations. The main offences under Part IV relate to failing to comply with a Part IV approval (sections 47 and 48).

Part V of the EP Act provides requirements for environmental licensing and pollution control. The failure to properly implement a closure plan may result in offences being committed against these provisions. The main potential offences relate to the pollution control offences created by sections 49, 50, 50A, 50B, 51, 51C, 58, 65 and 73 of the EP Act.

## 4.2 Limitation periods

A prosecution for a Tier 1 offence (e.g. pollution and environmental harm offences, and breach of Ministerial Statement conditions) may be brought at any time.

Prosecutions for other offences under the EP Act can only be brought within 24 months of either that date on which:

- the alleged offence was committed; or
- the day on which evidence of the alleged offence first came to the attention of a person authorised to institute the prosecution.

The effect of the second limb is that the risk of prosecution continues until 24 months of when the relevant authority becomes aware.

## 4.3 Section 47 – Ministerial approval

Ministerial Statements, which approve the implementation of proposals and which set out the commitments to be fulfilled by the proponent in implementing a proposal, invariably contain conditions which impart obligations on proponents. In the case of current mining proposals, many conditions will impart obligations on proponents which continue to run until closure of the mine. Section 47 of the EP Act provides that it is an offence not to comply with ministerial conditions and a maximum penalty of $250,000 applies to a corporation, with a daily penalty of $50,000.

As discussed above, proponents may be required to submit and comply with a MCP under a condition of a Ministerial Statement. If this is the case, a mining company that breaches an obligation contained in such a MCP would commit an offence under s 47 of the EP Act.

Risk categorisation = extinguishable liability. RTIO's potential liability will be largely relinquished upon expiry of the Ministerial Approval.

## 4.4 Section 48 – Control of Implementation of proposal

If RTIO fails to comply with a Ministerial Condition or procedure or does not fully comply with its monitoring obligations, and the Minister issues an order requiring RTIO to:

1 stop the implementation of its proposal for a period not exceeding 24 hours; and

2 take certain steps for the purpose of complying with a Condition or procedure of an implementation proposal, or for preventing, controlling or abating any Pollution or Environmental Harm caused by the non-compliance with the Condition or procedure,

then it is an offence for RTIO to fail to comply with such order.

The offence carries a maximum penalty of $325,000 for a corporation, with a daily penalty of $65,000.

Risk categorisation = ongoing liability.

## 4.5 Section 49 – Causing pollution

Section 49 provides for offences by any 'person who causes pollution or allows pollution to be caused,' with or without intention or criminal negligence.

'Pollution' means direct or indirect alteration to the environment:

(a) to its detriment or degradation;

(b) to the detriment of an environmental value; or

(c) of a prescribed kind,

that involves an emission.

'Emission' means:

(a) discharge of waste;

(b) emission of noise, odour or electromagnetic radiation; or

(c) transmission of electromagnetic radiation.

The offence of pollution is a Tier 1 offence which may attract penalties of up to $1,000,000 for companies with a daily penalty of up to $200,000 or $500,000 or five years imprisonment or both for individuals (including directors, officers and employees of a company) with a daily penalty of up to $100,000.

The penalty for this offence is greater if it occurs with intent or criminal negligence.

Risk categorisation = ongoing liability. RTIO's potential liability will continue after closure.

## 4.6 Section 49 – Unreasonable emissions

Section 49 provides for offences by any person who with or without intention or criminal negligence:

(a) emits an unreasonable emission from any premises; or

(b) causes an unreasonable emission to be emitted from any premises.

'Unreasonable emission' means an emission or transmission of noise, odour or electromagnetic radiation which unreasonably interferes with the health, welfare, convenience, comfort or amenity of any person.

A reference in the EP Act to the discharge, emission or transmission of anything (whether accompanied by the expression 'into the environment' or not):

(a) is a reference to discharge, emission or transmission onto or into land, water, the atmosphere or living things; and

(b) in relation to discharge, emission or transmission from premises, includes a reference to discharge, emission or transmission onto or into land, water, the atmosphere or living things on, in, under, above or part of the premises.

This offence is either a Tier 1 or Tier 2 offence which may attract penalties of up to $250,000 for companies with a daily penalty of up to $50,000; or $125,000 for individuals (including directors, officers and employees of a company) with a daily penalty of up to $25,000.

The penalty for this offence is greater if it occurs with intent or criminal negligence.

Risk categorisation = ongoing liability. RTIO's potential liability will continue after closure.

## 4.7 Section 49A

It is an offence to discharge or abandon any solid or liquid waste either:

(a) in water to which the public has access; or

(b) any other place.

The offence is a Tier 2 offence which attracts penalties of up to $125,000 for companies or $62,500 for individuals.

Risk categorisation = ongoing liability. RTIO's potential liability will continue after closure.

## 4.8 Sections 50A and 50 B - Environmental harm

It is an offence to either cause or allow to be caused material environmental harm or serious environmental harm.

Environmental harm includes an alteration of the environment to the detriment or potential detriment of an environmental value. An environmental value may relate to either ecosystem health, or to a beneficial use.

'Material environmental harm' means environmental harm that -

(a) is neither trivial nor negligible; or

(b) results in actual or potential loss, property damage or damage cost of an amount, or amounts in aggregate, exceeding the threshold amount.

'Serious environmental harm' means environmental harm that -

(a) is irreversible, of a high impact or on a wide scale;

(b) is significant or in an area of high conservation value or special significance; or

(c) results in actual or potential loss, property damage or damage costs of an amount, or amounts in aggregate, exceeding five times the threshold amount.

The threshold amounts prescribed for material environmental harm and serious environmental harm are $20,000 and $100,000 respectively.

The threshold amount does not have to be exceeded in any case to constitute either material or serious environmental harm. For example, where no monetary loss arises, material environmental harm may still occur where the harm is neither trivial nor negligible.

The damage costs referred to in the definitions in relation to the threshold amounts include not only those costs for controlling or abating the discharge but also any costs involved in making good the environment. It is likely there will be many scenarios where the damage costs will either exceed, or have the potential to exceed, the threshold amount of $20,000 thereby creating an offence of material environmental harm. (Note that actual or potential loss may be measured for the threshold amount).

The penalty for environmental harm is greatest if it occurs with intent or criminal negligence. Serious environmental harm is a Tier 1 offence with a penalty of up to $1,000,000 for companies and $500,000 for individuals and up to 5 years imprisonment. The penalty for material environmental harm is up to $500,000 for companies and $250,000 and up to 3 years imprisonment for an individual.

Risk categorisation = ongoing liability. RTIO's potential liability will continue after closure.

## 4.9 Section 50 - Discharge of waste likely to cause pollution

Section 50 provides for the offence by any person who, intentionally or with criminal negligence, causes or allows waste to be placed in any position which is likely to result in pollution.

This is a Tier 1 offence which may attract penalties of up to $1,000,000 for companies with a daily penalty of up to $200,000 or $500,000 for individuals (including directors, officers and employees of a company) with a daily penalty of up to $100,000.

Risk categorisation = ongoing liability. RTIO's potential liability will continue after closure.

## 4.10 Section 51 – Occupiers of premises to take certain measures

Section 51 provides for the offence by an occupier of any premises who does not take all reasonable and practical measures to prevent or minimise emissions from those premises which do not comply with the prescribed standard.

This offence is a Tier 2 offence with a maximum penalty of $25,000 for an individual or a body corporate and a maximum daily penalty of $5,000.

Risk categorisation = extinguishable liability. RTIO's potential liability will be largely relinquished upon ceasing to occupy the relevant sites.

## 4.11 Section 51C – Unauthorised clearing

It is an offence to cause or allow clearing of native vegetation otherwise than in accordance with a clearing permit unless it is an exempt matter under Schedule 6 of the EP Act or the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* (WA) (**Clearing Regulations**) (provided that it is not done in an environmentally sensitive area). Environmentally sensitive areas are declared in the Environmental Protection *(Environmentally Sensitive Areas) Notice 2005* (WA) by the Minister under Section 51B of the EP Act.

This offence is a Tier 1 offence with penalties up to $500,000 for a corporation with a daily penalty of up to $100,000 and $250,000 for an individual with a daily penalty of up to $50,000.

The exemptions listed in Schedule 6 of the EP Act are too numerous to mention. However, of relevance to RTIO is where the clearing is done in accordance with either a Part IV approval or in accordance with a works approval or licence. The Clearing Regulations provide further exemptions.

The CEO of the Department of Environment Regulation (**DER**) is able to apply for a clearing injunction before the Supreme Court to stop clearing that is not authorised. The Court is given a broad discretion to grant an injunction whether or not it is proved that a person intends to engage in any improper conduct (section 51S).

The EP Act provides that an occupier of a property will be deemed to have caused the clearing and the owner of the property will be deemed to have allowed the clearing in relation to the offence of unauthorised clearing unless the owner or occupier proves otherwise (section 51R).

A vegetation conservation notice may now be imposed by the CEO to require any damage caused by unauthorised clearing to be remedied or to re-establish vegetation to the state it was in prior to clearing (section 70).

Risk categorisation = ongoing liability. RTIO's potential liability for remediation of damage caused pre- or post-closure will continue.

## 4.12 Section 58 – Breach of environmental licence

Environmental licences are issued under Part V of the EP Act for all prescribed premises. Sites of relevance include processing/refinery operations, landfill sites and sewage facilities. Conditions of an environmental licence are generally aimed at the prevention and monitoring of waste discharges from premises and the breaching of any condition. Section 58 makes it an offence to breach a condition of an environmental licence. This is a strict liability offence, and is a Tier 2 offence with a maximum penalty of $125,000 for a body corporate and a maximum daily penalty of $25,000.

Risk categorisation = extinguishable liability. RTIO's potential liability will be relinquished upon expiry of the relevant licences and the expiry of the 2 year limitation period for breaches of licence that occurred prior to expiry.

## 4.13 Section 65 – Environmental protection notice (EPN)

EPNs are issued under Section 65 of the EP Act where there is or is likely to be an emission from any premises into the environment and the emission has caused or is likely to cause pollution or environmental harm. An EPN can be served on the 'owner' or the 'occupier' of the premises and only relates to current or future emissions.

An EPN may require a person to do one or more of the following:

(a) investigate the extent and nature of:

- the emissions and their consequences;
- the pollution and its consequences; or
- the environmental harm and its consequences;

(b) prepare and implement a plan for the prevention, control and abatement of the emission, pollution or environmental harm;

(c) take such measures as the CEO considers necessary to:

- prevent, control or abate the emission, pollution or environmental harm;
- comply with the standard;

(d) ensure that the amount or concentration of waste, noise, odour or electromagnetic radiation emitted from the premises, when measured at a point specified in the environmental protection notice, does not exceed the limit specified in the notice; or

(e) monitor the effectiveness or report to the CEO on any actions taken under the above.

The recipient of an EPN is liable for the carrying out of those specified measures. It is an offence not to comply with the conditions of an EPN. The offence is a Tier 2 offence with a maximum penalty of $125,000 for a body corporate and a maximum daily penalty of $25,000. It is a Tier 1 offence to intentionally or with criminal negligence not comply with an EPN for which a maximum penalty of $500,000 for a body corporate and a maximum daily penalty of $100,000 applies.

Risk categorisation = ongoing liability. RTIO's potential liability will continue after closure.

## 4.14 Defence provisions

Section 74 of the EP Act provides a reasonable precautions type defence to various offences. A properly prepared and implemented closure plan will be a component of demonstrating this defence.

Section 74A provides a specific defence for causing pollution, or for causing serious environmental harm or material environmental harm. The person charged must prove that the pollution or harm occurred in the implementation of a proposal in accordance with an implementation agreement or decision (an approval under Part IV of the EP Act) or in accordance with other nominated authorisations or exemptions under the EP Act (including a works approval or licence).

Section 74B provides a specific defence for serious or material environmental harm. Again, the defence requires some form of authorisation or approval or exemption under another written law or one of a number of specified soil and land related approvals.

## 4.15 Section 99T – Section 99ZA – Additional Court powers

Where a person is convicted of any offence under the EP Act, the Courts are empowered to craft innovative penalty orders which include payment for damage to property, rehabilitation, repayment of any economic benefit gained as a result of an offence and a requirement to publicise the offence in addition to the imposition of a penalty.

## 4.16 Section 118 - Liability of directors and others

A director, or a person who is concerned in the management of the company, will be deemed liable for an offence committed by the company (and may be prosecuted for that offence) unless that person can establish one of three defences under the Act. Those defences may broadly be described as:

- no knowledge or reasonable expectation of knowledge of the commission of the offence;
- that, if in a position of influence, the person had used all due diligence and reasonable precautions to prevent the offence from occurring; or
- the body corporate had a defence to the charge (e.g. authorised discharge).

They may also be charged for an offence of the body corporate without the company being charged, although the prosecution will have to make out its case against the company before the court for the charge against the director to stand.

The removal of the limitation period for Tier 1 offences described in detail below means that directors and managers may continue to be potentially liable for an offence committed by the company in perpetuity.

Risk categorisation = ongoing liability. The potential liability for RTIO's directors and other officers will continue after closure.

## 4.17 Third party action

Section 73B provides for a third party cause of action in tort against the company for damages for failure to comply with an EPN, a vegetation conservation notice or a prevention notice.

The damage must be caused to property not owned or occupied by RTIO. If the damage would not have been caused if the notice had been complied with, then, by reason of

RTIO's failure to comply, the owner or occupier of the damaged property has a right of action in tort against the person in respect of that damage.

Risk categorisation = ongoing liability. RTIO's potential liability will continue after closure, although is likely to be limited upon extinguishment of the relevant notice. Note that this provision does not expressly apply to closure notices. However, the common law rights for a third party to commence action remain 'post closure' (see part 21 below).

## 4.18 Financial assurances

Under Part VA, a proponent may be required to provide a financial assurance (akin to a bond) as a condition of a project approval issued under the EP Act. This is separate to a Mining Act performance bond (see part 7 below). The key risk here is that separate 'bonds' may apply to a project and be enforced by separate regulators under the EP Act as well as the Mining Act. As the EP Act applies to sites operated under a State Agreement Act, financial assurances can be imposed to cover such operations. These financial assurances apply as well as any royalty or other monetary obligations RTIO has under any State Agreement Act.

Financial assurances may be imposed under implementation conditions or conditions of an authorisation (such as an environmental licence, works approval or clearing permit). They may also be imposed by the CEO by written notice in relation to a closure notice, environmental protection notice, vegetation conservation notice or a prevention notice.

The CEO has the discretion to impose (with the Minister's consent) the financial assurance on a reasonable estimate of the total likely costs and expenses involved in addressing any financial matters the subject of the notice. If the financial assurance is insufficient, the CEO may recover additional costs. We note that the financial assurance only lapses on notice by the CEO. There may be situations where a closure notice or environmental protection notice is complete yet the CEO has not closed out the financial assurance. If a financial assurance requirement is imposed on the operation, RTIO's systems should acknowledge that the CEO's notice is required to obtain a return of the money that is the subject of the financial assurance.

Risk categorisation = ongoing liability. Although financial assurances may be imposed upon any authorisation, and therefore the risk of ongoing liability is minimised once the authorisation is relinquished, the potential for financial assurances to be imposed on closure notices means this is an ongoing liability risk for RTIO.

## 4.19 Emissions onto premises

The DER may regulate and enforce impacts (or potential impacts) of emissions within or outside the boundary of the premises. This applies to licensing emissions contained within the premises, notices, directions and prosecutions.

An emission contained on site may be the subject of regulatory action by the DER where there has been an impact (or potential impact) on an employee or other person or the wider site environment.

## 4.20 Other notices

Apart from EPNs (see para 4.13 above), the other notices available to the DER, include:

- closure notices (section 68A);
- ministerial stop order (section 69);
- vegetation conservation notices (section 70);

- environmental protection directions (section 71); and
- prevention notices (section 73A).

(a) Closure notices

The DER has the power to issue closure notices for operations nearing the cessation of activities. A closure notice may require a company to prepare a closure management plan, carry out investigations and require on-going monitoring. Independent audits of actions taken under a closure plan can also be required. The key risk here is increased scrutiny of closure operations from a regulator other than the DMP.

A closure notice may be the subject of a financial assurance as described in part 4.18 above.

The CEO may impose a closure notice if he considers on reasonable grounds that, as a result of anything that has been done, or has happened at a relevant premises before the expiry or revocation of an authorisation, ongoing investigation, monitoring or management is or will be required at the premises following the expiry or revocation.

The closure notice may be issued either during or after the lapsing of the relevant authorisation.

(b) Stop orders

The Minister may impose an order on a person to stop a process or activity if she considers that a person who is bound by an environmental protection notice has not complied with the notice, and the non-compliance has, is, or is about to cause conditions seriously detrimental to the environment or dangerous to human life or health.

(c) Vegetation conservation notices

Vegetation conservation notices may be imposed if the CEO suspects that unlawful clearing is likely to take place on any land, or has or is taking place on any land. Such a notice can require the person bound by the notice to repair any damage caused by the clearing and re-establish the vegetation to the state it was in prior to the clearing.

(d) Environmental protection directions

The CEO has the power to direct that the carrying on of any specific industry, trade or activity be prohibited or be subject to specific restrictions if he is satisfied that pollution, material environmental harm or serious environmental harm is occurring or is likely to occur.

(e) Prevention notices

If it is suspected that:

- any waste has been or is being discharged from any premises otherwise than in accordance with a works approval, licence or requirement contained in a closure notice or an environmental protection notice;
- a condition of pollution is likely to arise or has arisen; or
- a person has done, is doing, or is likely to do, an act in contravention of the 'environmental harm' provisions (see part 4.8 above),

then a notice may be given to that person to remove, dispense or otherwise deal with the waste being discharged or prevent the condition of pollution or environmental harm from arising or control or abate that condition.

### 4.21 Other Environmental Protection Act issues

Numerous Environmental Protection policies (**Policies**) have been made under Part III of the EP Act. These Policies have the force of law as though they are enacted as part of the EP Act. No Policies currently apply to RTIO operations in the Pilbara, however relevant Policies may be gazetted in the future.

## 5 Environmental Protection Regulations

### 5.1 Controlled waste

*The Environmental Protection (Controlled Waste) Regulations 2004* (**CW Regulations**) regulate the storage and transport of controlled wastes in WA.

A controlled waste is one that is listed by the CW Regulations. Examples of listed controlled wastes that are likely to be relevant to closure planning include:

- battery components such as acid, lead and cadmium;
- containers or drums that are contaminated with residues of a controlled waste;
- waste mineral oils that are unfit for their intended use;
- soils contaminated with a controlled waste; and
- tyres.

The CW Regulations require that licences be obtained:

- by carriers who transport or cause to be transported for gain or reward on a road a controlled waste;
- by a subcontractor of a carrier to transport on a road a controlled waste;
- by a person who is employed or engaged by a carrier to drive a vehicle of the carrier to transport a controlled waste on a road; and
- for vehicles or tanks used by carriers to transport a controlled waste.

The CW Regulations also impose direct obligations on the waste holder or generator to ensure compliance by subcontractors. Alternatively, RTIO may be liable for aiding and abetting a breach by subcontractors. Breaches by a subcontractor may also have reputational risks for RTIO.

The maximum penalty for a company for breaching the CW Regulations is a fine of $25,000. Risk categorisation = extinguishable liability. RTIO's potential liability will be largely extinguished upon expiry of the relevant licences and ceasing to store and transport controlled waste.

### 5.2 Unauthorised discharges

The *Environmental Protection (Unauthorised Discharges) Regulations 2004* (WA) provide for an offence for causing or allowing the discharge of materials listed in schedule 1 into the environment. This regulation operates in addition to the emission based offences

under the EP Act. No offence is committed if the discharge was authorised under another written law.

These regulations are likely to capture incidents which are of insufficient environmental impact to constitute emission based offences under the EP Act.

Examples of materials listed in Schedule 1 include:

- acid with a pH less than 4;
- alkali with a pH more than 10;
- compounds or solutions of cyanide, chromium, cadmium, lead, arsenic, mercury, nickel, zinc or copper;
- petrol, diesel or other hydrocarbon; and
- sewage.

The maximum penalty for a company is $25,000.

Risk categorisation = ongoing liability. RTIO's potential liability will continue after closure.

## 6 Environment Protection and Biodiversity Conservation Act

The *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (**EPBC Act**) contains the Commonwealth regime for environmental impact assessment. The existing operations of RTIO will not require approval under this legislation if the action is a lawful continuation of the use that was occurring or approved before the EPBC Act came into operation (16 July 2000). All other actions that will have or are likely to have a significant effect on a matter of national environmental significance will require assessment. The matters of national environmental significance are identified as:

- listed threatened species and ecological communities;
- migratory species protected under international agreements;
- Ramsar wetlands;
- Commonwealth marine areas;
- World Heritage properties;
- National Heritage places; and
- nuclear actions, including uranium mining.

Assessment or approval is given according to three procedures:

1 an approval by the Commonwealth Minister for the Environment (Ministerial Approval);

2 by approval from another Commonwealth decision maker under a management plan accredited by the Commonwealth Environment Minister for the purposes of Ministerial declaration (Ministerial Declaration); or

3 by State approval made in accordance with a management plan accredited by the Commonwealth Environment Minister for the purposes of a bilateral agreement. An assessment is triggered by referral from the proponent, a Commonwealth or State agency, or called in by the Commonwealth Minister for the Environment.

# 7 Contaminated Sites Act

The *Contaminated Sites Act 2003* (**CS Act**) and the associated *Contaminated Sites Regulations 2006* (WA) came into effect on 1 December 2006. This Act provides for the identification, recording, management and remediation of contaminated sites.

RTIO should note in its closure plans that the CS Act will have implications for closure liability for RTIO. All identified areas of known and/or potential contamination should be recorded as they will need to be dealt with for closure.

In accordance with the definition of 'contaminated' in section 4 of the CS Act, a site will be considered to be contaminated where the following two elements are satisfied:

(a) there is a substance in or on the land, water or site at above background concentrations; and

(b) the substance presents, or has the potential to present a risk of harm to human health, the environment or any environmental value.

The term 'contaminated' was intentionally defined broadly, so as to support the objects of the CS Act, which are to protect human health, the environment and environmental values by providing for the identification, recording, management and remediation of all contaminated sites in the State. In the Second Reading Speech of the *Contaminated Sites Bill 2002* (WA) the Minister for Environment and Heritage, Dr Judith Edwards, stated that the Bill was intended to address issues including the lack of information around contaminated sites. Dr Edwards went on to state:

> *One might ask: what is a contaminated site? It is important that the definition be broad enough to capture all forms of contamination that pose a problem, but not so broad as to lead to unnecessary bureaucracy where there is no risk. Therefore, the Bill uses a definition of "contaminated" in clause 4 that is risk based. It is not sufficient that a substance is present above a trigger level, there must also be some credible pathway by which it could pose a risk to human health or the environment.*

The DER Fact Sheet, *Mine Sites and the Contaminated Sites Act 2003* states that the duty to report is deliberately broad, to ensure that all contaminated sites are identified and recorded and that there are no exceptions for mining operations. The DER also states that companies ought to take a 'low risk' approach as to what is considered to be a contaminated site.

RTIO is required to report any sites that it knows or reasonably suspects are contaminated in accordance with the CS Act. However, in our experience, the DER has been willing to accept non-reporting of sites that do not require remediation although they may technically be 'contaminated' under the CS Act. Relying on the regulator's guidance in this respect should be carefully considered, Although, in these circumstances, the likelihood of prosecution for failure to report is low unless there is third party interest in the issue.

In particular, acid mine drainage may trigger a reporting requirement. The DER's stated policy is that the presence of naturally occurring acid sulphate soils in an undisturbed state will not make a site contaminated. However, where disturbance has resulted in concentrations of contaminants and/or a level of acidity within soils, sediments and waters that are above background concentrations and present, or have the potential to present, a risk of harm to human health, the environment or any environmental value the site will be 'contaminated'.

Once reported, the sites will be placed on a publicly available database and then dealt with according to the provisions of the CS Act. Of relevance to closure is that:

- a memorial may be placed on the title restricting the use, development and sale of the site;
- various notices may be issued under the EP Act or the CS Act relating to investigation and clean up;
- remediation obligations may be imposed on RTIO; and
- financial assurances may be required from RTIO to meet the closure requirements.

It is important to note that the hierarchy of responsibility under the CS Act means that RTIO may be liable for contamination on sites that it currently owns/occupies **and** sites that it has owned/occupied in the past. RTIO will also be responsible for sites that it has never owner or occupied, but which it has contaminated due to practices on its land that have caused contamination on other land.

Section 29 of the CS Act provides that the State will only be liable to remediate a contaminated site if no other person is responsible for remediation (ie the person who caused or contributed to the contamination, the owner of the contaminated site or a source site or the owner or occupier of a contaminated site who has changed the use of the land) or if the person responsible for remediation for the site cannot be identified or cannot be made to assume responsibility after reasonable attempts have been made to do so. In the mining context this would represent a very small number of sites.

Risk categorisation = ongoing liability. RTIO's potential liability will continue after closure.

# 8 Conservation and Land Management Act

The *Conservation and Land Management Act 1984* (WA) requires RTIO to ensure that it does not, in relation to any CALM land, amongst other things:

- unlawfully alter, obliterate, deface, pull up, remove, or destroy any boundary mark, or any stamp, mark, sign, licence, permit or order used or issued by the CEO of the DER or any authorised officer;
- unlawfully cut, break, throw down or in any way destroy or damage any building, fence, or gate, in or enclosing any land; or
- fail or refuse to comply with any lawful direction of an authorised officer (s107).

These obligations apply during the mine closure process, until RTIO has vacated the land. These obligations apply to the 'land based' aspects of the sites. The maximum penalty for a company for failing to comply with these provisions is $50,000.

Risk categorisation = extinguishable liability. RTIO's potential liability will largely be relinquished upon ceasing to occupy the premises.

# 9 State agreements

All of RTIO's mining, port and rail operations and a significant proportion of supporting infrastructure are situated on State Agreement tenure and operated in accordance with State Agreement provisions rather than the Mining Act. As such, RTIO must identify and comply with any relevant closure obligations in those agreements. Some of these

agreements have express closure obligations, or closure obligations may arise through commitments made in required environmental management programmes or development proposals submitted pursuant to those State Agreements. Where this occurs those obligations have been identified in the relevant State Agreement section below.

Each State agreement is different and should be included in the review of the specific closure obligations applicable to particular RTIO mining operations.

RTIO is currently a signatory to the following State agreements:

- *Iron Ore (Channar Joint Venture) Agreement Act 1987;*
- *Iron Ore (Hamersley Range) Agreement Act 1963;*
- *Iron Ore (Hamersley Range) Agreement Act 1968 (Paraburdoo);*
- *Iron Ore (Hope Downs) Agreement Act 1992;*
- *Iron Ore (Mount Bruce) Agreement Act 1972;*
- *Iron Ore (Robe River) Agreement Act 1964;*
- *Iron Ore (Rhodes Ridge) Agreement Authorisation Act 1972;* and
- *Iron Ore (Yandicoogina) Agreement Act 1996*,

a summary of the obligations relevant to mine closure in these agreements is below.

The provisions of a State Agreement entered into after the enactment of the EP Act do not exclude the operation of the EP Act, and do not have the effect of replacing or reducing the general obligations arising under that Act. The RTIO State Agreements have been amended to expressly provide for this. So for example, an approval under the EP Act, such as a Ministerial Statement issued pursuant to Part IV of the EP Act may still require RTIO to submit an MCP even if not required by the terms of the Agreement.

Generally, the approval provisions contained in the Mining Act do not apply to State Agreement operations, however this will depend on the nature or conditions of the mineral lease or other tenure granted pursuant to the State Agreement.

## 9.1 Iron Ore (Channar Joint Venture) Agreement Act 1987

Clause 7 provides that RTIO must have, by 30 June 1988, submitted to the Minister to the fullest extent reasonably practicable, its detailed proposals with respect to the mining, transport and shipment of iron ore. Those proposals are required to include an environmental management programme as to measures to be taken under the Agreement, for the protection and management of the environment.

Clause 9(7) requires RTIO to implement the approved proposals (as well as any Additional Proposals under clause 10) in accordance with their terms. This could include any closure, rehabilitation or other commitments made in those proposals.

Clause 11 specifies that, in relation to the matters referred to in paragraph (i) of subclause (3) of Clause 7 (ie the environmental management programme) RTIO shall carry out continuous monitoring programme to ascertain the effectiveness of the measures it is taking pursuant to its approved proposals for rehabilitation and protection and management of the environment. RTIO is also required to submit a detailed report to the Minister from time to time.

Furthermore, if RTIO, as a result of this monitoring or otherwise discovers any new information which in order to more effectively rehabilitate the Channar site may necessitate any changes or additions to any approved proposals or require matters not addressed in approved proposals to be addressed, RTIO must inform the Minister. This notification must include a detailed report of the information. The Minister may then

require further detailed proposals to be submitted by RTIO. If so, RTIO must then submit such proposals to the Minister within 2 months.

Clause 40 provides that, at the cessation or termination of the Agreement, all buildings, erections and other improvements erected on any land occupied by the Joint Venturers under the mining lease or any other lease, licence, easement, grant or other title made under the Agreement will become the property of the State. If prior to this date the Joint Venturers wish to remove any of their fixed or moveable plant and equipment they may do so, provided they grant the State the right or option within three months to purchase it at a fair value, except where the plant or equipment is on land to be included in Mineral Lease 4SA or otherwise leased or granted by the State to Hamersley pursuant to the provisions of the Agreement dated 30 July 1963 approved by the *Iron Ore (Hamersley Range) Agreement Act 1963*.

Clause 41 provides that:

> Nothing in this Agreement shall be construed to exempt the Joint Venturers from compliance with any requirement in connection with the protection of the environment arising out of or incidental to their activities hereunder that may be made by the State or by any State agency or instrumentality or any local or other authority or statutory body of the State pursuant to any Act from time to time in force.

Risk categorisation = extinguishable liability. RTIO's potential liability will be largely relinquished upon cessation or determination of this Agreement.

## 9.2 Iron Ore (Hamersley Range) Agreement Act 1963 and Iron Ore (Hamersley Range) Agreement Act Amendment Act 1968 (Paraburdoo)

The Interpretation clause provides that:

> Nothing in this Agreement shall be construed to exempt the Company from:
>
> (a) compliance with any requirement in connection with the protection of the environment arising out of or incidental to its activities under this Agreement that may be made by or under the EP Act;
>
> (b) to exempt the State or the Company from compliance with or to require the State or the Company to do anything contrary to any laws relating to native title or any lawful obligation or requirement imposed on the State or the Company as the case may be pursuant to any laws relating to native title; or
>
> (c) the AH Act.

As a result, RTIO must comply with the closure obligations contained in, or arising from approvals granted under the EP Act, any native title legislation and the AH Act.

Clause 10I(2) provides that RTIO must have, by 1 October 1990, submitted detailed proposals to the Minister with respect to the mining of iron ore from the Brockman No.2 Detritals deposit (including for transportation of the ore). This must include an environmental management programme as to measures to be taken, in respect of the Company's activities at the Brockman No.2 Detritals Deposit, for rehabilitation and the protection and management of the environment. Clause 10I(10) provides that if RTIO wishes to significantly modify, expand or otherwise vary the Brockman No. 2 Detritals Deposit, beyond those specified in approved proposals, then it is required to submit a further proposal, which is required to include details of a further environmental management programme, including further details of rehabilitation. Clause 10I(11) specifies that RTIO shall carry out continuous monitoring programme to ascertain the

effectiveness of the measures it is taking pursuant to rehabilitation proposals. . Clause 10I(11) also provides that RTIO must submit annual brief reports to the relevant Minister and three-yearly comprehensive reports on possible further implementation measures arising as a result of the monitoring conducted.

Clause 10G provides that should RTIO wish to significantly modify its operations in connection with the provision of services for the Channar Agreement, or enter into an agreement for the mining of iron ore from the mining lease granted under the Channar Agreement,(other than the Brockman No.2 Detritals Deposit), RTIO must submit a proposal to the Minister. This proposal must include environmental management measures, and any other matters as the Minister may require, such as a closure or rehabilitation plan.

Clause 11(e) provides that, at the determination of any lease license or easement granted under the Agreement, the improvements and things erected on the relevant land and provided for in connection therewith must remain or will become the property of the State. However if prior to this date RTIO wishes to remove locomotives, rolling stock, plant, equipment and/or removable buildings it may do so, provided it notifies the State and grants the State the right or option within three months to purchase it at a fair value.

Risk categorisation = extinguishable liability. RTIO's potential liability will be largely relinquished upon cessation or determination of this Agreement.

## 9.3 Iron Ore (Hope Downs) Agreement Act 1992

Clause 2A provides that:

> Nothing in this Agreement shall be construed:
>
> (a) to exempt the Company from compliance with any requirement in connection with the protection of the environment arising out of or incidental to its activities under this Agreement that may be made by or under the EP Act; or
>
> (b) to exempt the State or the Company from compliance with or to require the State or the Company to do anything contrary to any laws relating to native title or any lawful obligation or requirement imposed on the State or the Company as the case may be pursuant to any laws relating to native title; or
>
> (c) to exempt the Company from compliance with the provisions of the AH Act.

As a result, RTIO must comply with the closure obligations contained in the EP Act, AH Act and any native title legislation.

Clause 3 of the Act provides that the State must give RTIO access to the Crown Land at Hope Downs subject to the adequate protection of the environment and flora and fauna.

Clause 7 provides that RTIO must have by 30 June 1998, submitted to the Minister to the fullest extent reasonably practicable, its detailed proposals with respect to the mining, transport and shipment of iron ore. Those proposals are required to include an environmental management programme as to the measures to be taken under the Agreement, for the protection and management of the environment.

Clause 8(6) requires RTIO to implement the approved proposals (as well as any Additional Proposals under clause 10) in accordance with their terms. This could include any closure, rehabilitation or other commitments made in those proposals.

Clause 15 specifies that, in relation to the matters referred to in paragraph (m) of subclause (1) of Clause 7 (ie the environmental management programme) RTIO should

carry out continuous monitoring programme to ascertain the effectiveness of the measures it is taking pursuant to its approved proposals for rehabilitation, protection and management of the environment.

Clause 15 also provides that RTIO must submit annual brief reports to the relevant Minister and three-yearly comprehensive reports on possible further implementation measures arising as a result of the monitoring conducted.

Clause 15(4) further specifies that on or the date occurring 2 years after the East Angelas Deposit is included in the Hope Downs mining lease, RTIO must have submitted to the Minister, to the fullest extent reasonably practicable, its detailed proposals with respect to the mining, transport and shipment of iron ore. Those proposals are required to include an environmental management programme as to the measures to be taken under the Agreement, for the protection and management of the environment.

Clause 38 provides that, upon the cessation or termination of the Agreement, all buildings, erections and other improvements erected on any land occupied by the Company under the mining lease or any other lease, licence, easement, grant or other title made under the Agreement will become the property of the State. If prior to this date the Company wishes to remove any of their fixed or moveable plant and equipment they may do so, provided they grant the State the right or option within three months to purchase it at a fair value.

Risk categorisation = extinguishable liability. RTIO's potential liability will be largely relinquished upon cessation or determination of this Agreement.

## 9.4 Iron Ore (Mount Bruce) Agreement Act 1972

Clause 23 provides that, at the cessation or determination of any lease license or easement granted under the Agreement, the improvements and things other than plant, equipment and removable buildings erected on the relevant land and provided for in connection therewith must remain or will become the property of the State. However if prior to this date RTIO wishes to remove locomotives, rolling stock, plant, equipment and/or removable buildings it may do so, provided it grants the State the right or option within three months to purchase it at a fair value.

Clause 30 provides that:

> Nothing in this Agreement shall be construed:
>
> (a) to exempt the Company from compliance with any requirement in connection with the protection of the environment arising out of or incidental to its activities under this Agreement that may be made by or under the EP Act; or
>
> (b) to exempt the State or the Company from compliance with or to require the State or the Company to do anything contrary to any laws relating to native title or any lawful obligation or requirement imposed on the State or the Company as the case may be pursuant to any laws relating to native title; or
>
> (c) to exempt the Company from compliance with the provisions of the AH Act.

As a result, RTIO must comply with the closure obligations contained in the EP Act and any conditions which are attached to approvals obtained under that Act, the AH Act and any native title legislation.

Risk categorisation = extinguishable liability. RTIO's potential liability will be largely relinquished upon cessation or determination of this Agreement.

## 9.5 Iron Ore (Robe River) Agreement Act 1964

The Interpretation clause provides that:

> Nothing in the Act operates:
>
> (a) to exempt the Company from compliance with any requirement in connection with the protection of the environment arising out of or incidental to its activities under this Agreement that may be made by or under the EP Act; or
>
> (b) to exempt the State or the Company from compliance with or to require the State or the Company to do anything contrary to any laws relating to native title or any lawful obligation or requirement imposed on the State or the Company as the case may be pursuant to any laws relating to native title; or
>
> (c) to exempt the Company from compliance with the provisions of the *AH Act*.

As a result, RTIO must comply with the closure obligations contained in the EP Act, the AH Act and any native title legislation.

Clause 5(2) provides that RTIO must as soon as practicable after giving notice pursuant to cluse 5(1), submitted to the Minister to the fullest extent reasonably practicable, its detailed proposals with respect to the mining, transport and shipment of iron ore. Those proposals are required to include an environmental management programme as to the measures to be taken under the Agreement, for the protection and management of the environment.

Clause 7A provides that if RTIO proposes to significantly expand its operations under that Agreement, it must provide details in relation to the protection and management of the environment

Clause 7AC(1) provides that RTIO should carry out continuous monitoring programme to ascertain the effectiveness of the measures they are taking pursuant to rehabilitation proposals.

Clause 7AC(2) provides that RTIO must submit annual brief reports to the relevant Minister and three-yearly comprehensive reports on possible further implementation measures arising as a result of the monitoring conducted.

Clause 10(e) provides that, at the cessation or determination of any lease license or easement granted under the Agreement, the improvements and things erected on the relevant land and provided for in connection therewith must remain or will become the property of the State. However if prior to this date RTIO wishes to remove locomotives, rolling stock, plant and /or equipment it may do so, provided it grants the State the right or option within three months to purchase it at a fair value.

Risk categorisation = extinguishable liability. RTIO's potential liability will be largely relinquished upon cessation or determination of this Agreement.

## 9.6 Iron Ore (Yandicoogina) Agreement Act 1996

The Interpretation clause provides that:

> (2) Nothing in this Agreement shall be construed to exempt the State or the Company from compliance with, or to require the State or the Company to do anything contrary to, any law relating to native title or any lawful obligation or requirement imposed on the State or the Company, as the case may be, pursuant to any law relating to native title.

(3) Nothing in this Agreement shall be construed to exempt the Company from compliance with any requirement in connection with the protection of the environment arising out of or incidental to its activities under this Agreement that may be made pursuant to the EP Act.

(4) Nothing in this Agreement shall be construed to exempt the Company from compliance with the provisions of the AH Act.

As a result, RTIO must comply with the closure obligations contained in the EP Act and any conditions which are attached to approvals obtained under the Act, the AH Act and any native title legislation.

Clause 6 provides that RTIO must have by 31 December 1997, submitted to the Minister to the fullest extent reasonably practicable, its detailed proposals with respect to the mining, transport and shipment of iron ore. Those proposals are required to include an environmental management programme as to the measures to be taken under the Agreement, for the protection and management of the environment.

Clause 7(7) requires RTIO to implement the approved proposals in accordance with their terms. This could include any closure, rehabilitation or other commitments made in those proposals. Clause 9(1) states that if RTIO wishes to significantly modify, expand or otherwise vary its activities RTIO must submit an additional proposal to the Minister. Clause 9(2) provides that the requirements of clause 7(7) will apply to any additional proposals. That is, additional proposals must also be implemented in accordance with their terms.

Clause 13 specifies that, in relation to the matters referred to in paragraph (l) of subclause (1) of Clause 6 (ie the environmental management programme) RTIO shall carry out a continuous monitoring programme to ascertain the effectiveness of the measures it is taking pursuant to its approved proposals for rehabilitation, protection and management of the environment,

Clause 13 also provides that RTIO must submit annual brief reports to the relevant Minister and three-yearly comprehensive reports on possible further implementation measures arising as a result of the monitoring conducted.

Clause 39 provides that, upon the cessation or termination of the Agreement, all buildings, erections and other improvements erected on any land occupied by the Company under the mining lease or any other lease, licence, easement or other title made under the Agreement will become the property of the State. If prior to this date the Company wishes to remove any of their fixed or moveable plant and equipment they may do so, provided they grant the State the right or option within three months to purchase it at a fair value.

Risk categorisation = extinguishable liability. RTIO's potential liability will be largely relinquished upon cessation or determination of this Agreement.

## 9.7 Iron Ore (Rhodes Ridge) Agreement Authorisation Act 1972

Clause 5.02 provides that the Joint Venturers must, before the fifth anniversary of the commencement date of the Agreement or such later date as the Minister may approve, submit to the Minister detailed proposals which include appropriate plans and (where reasonably required by the Minister) appropriate specifications in respect of mining iron ore and the future development of mining areas and detailed particulars as to the measures proposed to be taken for the protection of the environment (which may include closure and rehabilitation measures).

Clause 7.01 provides that if the Joint Venturers wish to expand their activities beyond those specified in any approved proposal they must submit detailed proposals to the

Minister which includes measures proposed to be taken for the protection of the environment (which may include closure and rehabilitation measures).

Clause 10(e) provides that, at the cessation or determination of any lease, licence or easement granted under the Agreement, the improvements and things erected on the relevant land and provided for in connection therewith must remain or will become the property of the State. However if prior to this date RTIO wishes to remove locomotives, rolling stock, plant and /or equipment it may do so, provided it grants the State the right or option within three months to purchase it at a fair value.

Risk categorisation = extinguishable liability. RTIO's potential liability will be largely relinquished upon cessation or determination of this Agreement.

## 10 Mining Act

The *Mining Act 1978* (WA) (**Mining Act**) and the *Mining Regulations 1981* (WA) (**Mining Regulations**) contain specific requirements for the management of mining leases. Mining Act leases may give rise to the requirements outlined below.

The definition of 'mining proposal' in the Mining Act now includes a MCP. This will apply to all new mining proposals. With respect to existing projects, tenement conditions may be imposed requiring the submission of a MCP. For the majority of RTIO projects which operate on State Agreement tenure, the requirement to submit an MCP pursuant to the Mining Act is not applicable.

In addition to the requirement to submit an MCP, closure may be regulated as a condition of a mining lease imposed at the time approval to mine is granted, or under section 84 of the Mining Act which allows the Minister to impose, at any time, reasonable conditions for the purpose of preventing, reducing, or making good injury to the land.

Further, Regulation 28 of the Mining Regulations states that it is a condition of every mining lease that all holes, pits, trenches and other disturbances to the surface of the land made while mining which, in the opinion of a person holding or acting in the office of Environmental Officer in the Environmental Division of the DMP (**Environmental Officer**) are likely to endanger the safety of any person or animal will be filled in or otherwise made safe to the satisfaction of an Environmental Officer.

Prior to the commencement of mining, it is a common requirement placed on miners to provide a financial security or performance bond to cover the conditions attaching to the mining lease and the relevant provisions of the Mining Act and Mining Regulations including the decommissioning and rehabilitation of mine sites. The bonds are required for the life of the project and are only retired when the lessee submits an audit of compliance with the mine lease conditions that is acceptable to the Minster/DMP (ss 84A and 126).

A breach of the Mining Act or Mining Regulations could expose RTIO to criminal prosecution and may give rise to a cause of action for breach of statutory duty at common law (see part 21 for further details).

Risk categorisation = extinguishable liability. RTIO's liability will largely cease upon sign-off on rehabilitation conditions under the provisions of the applicable tenement and return of the bond under the relevant tenement. This may not occur for some time post closure.

# 11 Parks and Reserves Act

The *Parks and Reserves Act 1895* (WA) allows local Boards (appointed under the Act) to make and enforce by-laws for a range of matters, including prohibiting damage or injury to and destruction of trees, shrubs, plants and flowers on the land. The scope of powers and obligations under the Act do not impose obligations on RTIO beyond those already imposed under other legislation, such as the EP Act and Mining Act.

RTIO should confirm whether the relevant Boards have made any applicable by-laws under this Act.

Risk categorisation = extinguishable liability. It is likely that any relevant provisions will cease upon relinquishment of land tenure and therefore RTIO is unlikely to have any ongoing liability.

# 12 Rights in Water and Irrigation Act

Licensing is required under the *Rights in Water and Irrigation Act 1914* (WA) (**RIWI Act**) for the use of all:

- surface water, except where otherwise provided as riparian rights or other domestic and ordinary usage rights;
- artesian underground water; and
- non-artesian underground water, within proclaimed ground water areas.

The licence may be made subject to conditions and will specify the extent to which water may be diverted, taken or used.

A licence may be granted or renewed for a fixed period or indefinite duration. Licences remain in force until terminated (cl 13 Schedule 1), suspended or cancelled (cl 25 Schedule 1) or surrendered (cl 27 Schedule 1).

The licensee may transfer the licence or water entitlements under the licence to a person eligible to hold a licence. This does not apply where relevant by-laws prohibit transfer of licences of that kind. A transfer of a licence or water entitlement cannot be made without the approval of the Minister (cl 31 Schedule 1). A decision of the Minister not to approve the transfer may be reviewed by the State Administrative Tribunal (s 26GG). RTIO should review its water licences and determine whether any of them will be tradeable upon closure of the sites.

RTIO may enter into an agreement with another person (**the third party**) relating to the taking of water under the licence by the third party for a limited period of time. RTIO should review all of its water licences to identify any agreements or obligations it has with third parties.

It is an offence to obstruct, destroy or interfere with any watercourse, race or drain flowing through or over private land, or any dam or reservoir, or the bed of any disused watercourse, race or drain on the land without being authorised to do so under the RIWI Act or any other legislation (s 17). It is also an offence to obstruct, destroy or interfere with any watercourse flowing through or over or any wetland situated on Crown land (s 25). Prosecutions for this offence may only be commenced within 2 years of when the offence was committed (ss 17(5) & 25(3)). If RTIO were to be convicted of such an offence arising during the site closure process, the Minister may require RTIO to carry out remedial works at its own cost (ss 17(6) & 25(4)).

Risk categorisation = ongoing liability. If RTIO was convicted of an offence then there is potential for the Minister to require RTIO to carry out remedial works for interference to watercourses or wetlands. If that is the case, RTIO's potential liability will continue after closure.

# 13 Wildlife Conservation Act

RTIO must ensure that it does not harm, destroy or take flora and fauna that is protected under the *Wildlife Conservation Act 1950* (WA). This obligation continues until RTIO has vacated the site.

Risk categorisation = extinguishable liability. RTIO's potential liability will be largely extinguished upon ceasing to occupy the premises.

# 14 Indigenous Issues

## 14.1 Indigenous Agreements

All participation agreements and any other agreements which RTIO has entered into with native title parties in relation to its operations should be reviewed to identify any obligations held by RTIO in relation to closure of those operations. Such obligations, if any, may relate to matters such as interests in land, or transfer of interests in certain infrastructure. While some of these native title claims may have been determined, the precise terms of the agreement between RTIO and the native title party will need to be reviewed in order to confirm whether the agreement will continue to apply.

As part of the review of the participation agreements, consideration should be given to the various "Regional Standards" which form part of the Regional Framework Deed. The standards require RTIO to undertake ongoing and regular consultation with each group (including consultation on closure issues). In particular the Environment and Life of Mine Planning standards should be considered, as both are relevant to closure.

Risk categorisation = ongoing liability. .

## 14.2 Aboriginal Heritage

(a) State Aboriginal Heritage protection legislation

The *Aboriginal Heritage Act 1972* (WA) (**AH Act**) provides that is an offence to alter an Aboriginal site in any way in the absence of Ministerial consent under section18 of the Act (**Section 18 Consent**), or the permission of the Registrar under section 16 of the Act (**Section 16 Permit**).

A person who, having consent or authorisation under section 18 and section 16 of the Act, is in breach of any condition to which the giving of the consent or authorisation was made subject, commits an offence (s 55). The maximum penalties under the Act range from $20,000 to $100,000, depending on whether it is an individual or body corporate, and whether it is the first or a subsequent offence. There is a daily penalty of $400 for an individual and $1,000 for a body corporate (s 57).

(b) Commonwealth Aboriginal Heritage protection legislation

The *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* (Cth) (**Cth Act**) applies to 'significant Aboriginal areas' following a declaration by the Commonwealth Minister under the Act in relation to a specific area. A declaration has the effect of prohibiting injury to, or the desecration of, the particular area, object or class of objects specified in the declaration, wherever it is situated. It is an offence to engage in conduct which contravenes the terms of such a declaration.

(c) The EPBC Act

As referred to in part 6 above, heritage matters, including indigenous heritage, may be matters of national environmental significance under the EPBC Act.

(d) Risk categorisation

Activities associated with the closure of operations should be assessed in terms of potential impact on Aboriginal Heritage, and to the extent that impact upon Aboriginal sites, if any, cannot be avoided then relevant consents should be obtained.

Risk categorisation = ongoing liability. Depending on the sites and consents applicable, RTIO may have ongoing liability post closure.

### 14.3 Native Title

The *Native Title Act 1993* (Cth) (**NTA**) provides that future acts can be invalid to the extent that they affect native title. If activities associated with closure involve the grant of any land tenure or interests, or any other act, which could affect native title, then it will be necessary to comply with the future act provisions of the NTA.

Risk categorisation = potential ongoing liability. Depending on whether native title claims exist and how they have been progressed, RTIO may have ongoing liability post closure.

### 14.4 Aboriginal Reserve Lands

Under the *Aboriginal Affairs Planning Authority Act 1972* (WA) (**AAPAA**), land which is reserved for the use and benefit of Aboriginal people may be proclaimed by the Governor as Reserved land to which Part III of the AAPAA applies. The AAPAA provides that it is an offence to enter or remain on land which has been so proclaimed without holding an entry permit issued by the Minister under the AAPAA regulations. If activities associated with closure involve entering or remaining on Aboriginal Reserve lands the then the relevant permits should be obtained.

Risk categorisation = potential ongoing liability depending on whether Aboriginal Reserve lands are impacted.

## 15 Mines Safety and Inspection Act

### 15.1 General

The following obligations may apply to all sites.

Occupational safety and health in mining operations is regulated by the *Mines Safety and Inspection Act 1994* (**MSI Act**) and the *Mines Safety and Inspection Regulations 1995* (**MSI Regulations**). RTIO must comply with the provisions of the MSI Act.

## 15.2 Duties in relation to operations

In relation to the operations for decommissioning or closure, the usual duties under the MSI Act will apply. These include the general duties of care which fall on RTIO as principal employer, employer, deemed employer, person in control of a workplace, etc. As a minimum, RTIO must undertake a hazard assessment of any relevant operations and put in place measures to minimise any identified risks.

## 15.3 Regulatory requirements for closure

The MSI Act and MSI Regulations also create specific obligations for the abandonment or suspension of mining operations. RTIO must notify the District Inspector for the relevant region in writing in the following circumstances:

- before mining operations are abandoned – section 42(1)(c); and
- before mining operations are suspended – section 42(1)(d).

The notification should be accompanied by evidence which satisfies the District Inspector that the requirements under the Act for the abandonment or suspension of mining operations have been fulfilled. Each notification must include the following details:

- the name and location of the mine – regulation 3.12(a);
- the number of the lease, tenement or other interest – regulation 3.12(b);
- the name and address of the principal employer – regulation 3.12(c);
- what mining operations are to be affected, and whether they are to be commenced, recommenced, abandoned or suspended – regulation 3.12(d); and
- the date on which the mining operations are to be commenced, recommenced, abandoned or suspended – regulation 3.12(e).

On receiving a notification, the District Inspector will inspect the mine and verify the evidence provided with the notice and make a record accordingly. Notification of the suspension of mining operations must also include the following information amongst other matters:

- the reason for the suspension and the planned duration of the suspension – regulation 3.14(a);
- whether the closure is total – regulation 3.14(b);
- the measures that have been taken to prevent unauthorised access or entry to the mine – regulation 3.14(d); and
- an accurate plan or plans of the mining operations to the time of suspension with the plan/s going to the State mining engineer before the mining operations are abandoned or suspended – regulation 3.14(f).

Notification of the abandonment of mining operations at a mine must also include the following information amongst other matters:

- details of precautions taken to ensure that all plant and equipment have been removed or secured and left in a safe condition – regulation 3.16(d);
- details of precautions taken to remove or properly dispose of all hazardous substances at the mine – regulation 3.16(e); and
- an accurate plan or plans of the mining operations to the time of abandonment with the plan/s going to the State mining engineer before the mining operations are abandoned or suspended – regulation 3.16(f).

If mining operations are abandoned or suspended RTIO must keep all record books and log books kept under the MSI Act in respect of the mine for a period for 6 years from the time of abandonment or suspension and take steps to ensure they are kept safe for that period if RTIO appears likely to go into liquidation or receivership (section 89(3) MSI Act).

A breach of the MSI Act or MSI Regulations could expose RTIO to criminal prosecution under the MSI Act and may give rise to a cause of action for breach of statutory duty at common law (see part 21.3 of this review for further details).

Risk categorisation = ongoing liability. RTIO's potential liability will continue after closure with respect to ensuring compliance with plans associated with closure.

## 16 Occupiers Liability Act

The following obligations may apply to all sites in relation to closure (as well as day to day operations).

At common law an occupier of land may owe a duty of care to visitors or the public who access the land. The *Occupiers Liability Act 1985* (WA) (**Occupiers Liability Act**) prescribes the standard of care where an occupier of land can be liable for loss, injury or damage suffered by people visiting the land as a result of dangers arising on the land.

As RTIO owes a duty of care to a person on its mine tenements, section 5(4) of the Occupiers Liability Act provides that consideration must be given to the following factors in determining how to discharge the duty:

(a) the gravity and likelihood of the probable injury;

(b) the circumstances of entry on the premises;

(c) the nature of the premises;

(d) the knowledge which the occupier of the premises has or ought to have of the likelihood of persons or property being on the premises;

(e) the age of the person entering the premises;

(f) the ability of the person entering the premises to appreciate the danger; and

(g) the burden on the occupier of eliminating the danger or protecting the person from entering the premises from danger as compared to the risk of danger to the person.

The Occupiers Liability Act does not expose RTIO to any specific liability, however, it does apply to establish the standard of care that will have to be met in the event that a negligence claim is brought against RTIO.

As a minimum, a risk assessment should be undertaken to determine what steps need to be taken to control relevant hazards. It is important to be aware that the liability extends to cases of an occupier creating dangers, and also failing to remove or warn of relevant dangers. We can provide further advice on this process if required.

Risk categorisation = extinguishable liability. RTIO's potential liability will be largely relinquished upon ceasing to occupy the premises.

## 17 Criminal Code Compilation Act

The Criminal Code is the Schedule to the *Criminal Code Act 1913*, which is Appendix B to the *Criminal Code Act Compilation Act 1913* (WA) (**Code**).

Section 304 of the Code makes it an offence if a person does an unlawful act or omits to do any act that it is the person's duty to do, as a result of:

(a) bodily harm is caused to any person; or

(b) the life, health or safety of any person is or is likely to be endangered.

The person is guilty of a crime and is liable to imprisonment for 5 years (or a summary conviction of $24,000 or imprisonment for 2 years). A maximum conviction of 20 years applies if the act or omission is committed with intent.

Risk categorisation = ongoing liability. RTIO's potential liability will continue after closure to the extent it remains responsible for certain activities on the premises.

## 18 Relevant workforce legislation

RTIO will need to comply with the relevant workplace relations legislation as well as employment contracts and industrial instruments in place at the time of closure.

The key issues will arise in relation to any terminations of employment which arise from cessation of mining operations and closure of sites.

RTIO will have obligations to seek to redeploy employees to other operations if possible. Issues may arise under employment contracts and industrial instruments as to who can be redeployed and on what terms.

In the event of redundancies, RTIO will need to comply with relevant legislative and industrial requirements. The *Workplace Relations Act* 1996 (Cth) contains requirements in relation to termination of employment and specifically in relation to terminations arising for genuine operational reasons (ie redundancies). There may also be some requirements arising under State industrial laws.

For example, there may be requirements to inform employees of proposed significant changes to operations and to inform relevant government departments (and possibly relevant unions) of proposed redundancies.

Failure to provide appropriate notice of termination or payment in lieu, payment of accrued leave entitlements, and severance payments may also lead to unfair or unlawful termination claims. It will also be important to ensure that any process for selection for redundancy versus redeployment does not include any prohibited grounds.

## 19 Agreements, Licences, Permits, Approvals and other tenure

Closure obligations may also be specified in agreements (including joint venture agreements), licences, permits and approvals. Each agreement, licence, permit or approval is likely to be different and should be included in the review of the specific closure obligations applicable to particular RTIO operations.

RTIO has land subject to tenure arrangements other than under State Agreements or the Mining Act. That tenure should be reviewed on a case by case basis to identify and understand any closure obligations that might arise from the tenure arrangements.

## 20 International Standards – ISO 14001:2004

International Standard 14001:2004 (**the Standard**):

- specifies the requirements for an environmental management system (**EMS**) to allow an organisation to develop and implement policies and objectives which take into account legal and other requirements to which it subscribes; and
- provides information about significant environmental aspects.

The Standard does not state specific environmental performance criteria itself and only applies to environmental aspects that the organisation identifies as those which it can control and influence. The revised ISO 14001:2004 does not make fundamental changes to ISO 14001:1996 but clarifies the purpose of the standard and increases alignment with the ISO 9001 Quality Management Systems standard. The revised ISO 14001:2004 places emphasis on compliance.

The Standard requires organisations to:

- establish, document, implement, maintain and continually improve their EMS and to determine how it will fulfil these requirements;
- implement and maintain procedures to identify the environmental aspects of its activities, products and services that it can control and influence;
- determine those aspects that have or can have significant impact on the environment;
- identify and have access to the applicable legal requirements and other requirements to which the organisation subscribes, and to determine how these requirements apply to its environmental aspects; and
- establish, implement and maintain documented environmental objectives and targets.

The revised ISO 14001:2004 requires organisations to comply with certain processes of implementation and operation of environmental management systems (including resources, roles, responsibility and authority; competence, training and awareness; communication; documentation; control of documents; operational control and emergency preparedness and response).

Further, an organisation must:

- establish, implement and maintain a procedure to monitor and measure, on a regular basis, the key characteristics of its operations that can have a significant environmental impact;
- periodically evaluate compliance with applicable legal requirements and other requirements;
- deal with actual and potential nonconformity and for taking corrective and preventative action;
- keep records as necessary to demonstrate conformity to its environmental management system and to the Standard;

- ensure that internal audits of the environmental management system are conducted; and
- (top management) review the environmental management system.

Effectively, ISO 14001:2004 provides procedures and compliance mechanisms with regards to:

- environmental aspects, objectives, targets and programmes;
- resources, roles, responsibility and authority;
- competence, training and awareness;
- communication;
- non-conformity, corrective and preventative action;
- internal audit; and
- management review.

International standards do not impose legally binding obligations on RTIO. However, compliance with these standards assists in providing evidence of compliance with best practice standards and on that basis, compliance with such standards may assist in a defence to a common law action (see part 21 below). Further, compliance with standards is also likely to assist in establishing that RTIO took all reasonable precautions and exercised due diligence to prevent the commissioning of certain offences under the EP Act (relevant to defences under the EP Act, see part 4.14 above) and other Acts.

# 21 Common Law Liability

Nuisance, negligence and breach of statutory duty are the three main common law actions which may be taken against RTIO in relation to its environmental or health and safety performance in closing a site. A summary of those actions is provided below.

## 21.1 Nuisance

Nuisance is based on the infringement of another person's rights to the enjoyment of their property or a public amenity. Liability is decided by whether the alleged nuisance is reasonable in the circumstances of the case. This usually depends on the nature of the locality, the extent of the nuisance and the actual or potential harm caused.

An affected person may take an action in nuisance where the environmental effects of site closure practices have caused or are causing material damage to the use of their property or a public amenity. If an action is taken, RTIO will have to establish that its closure practices were reasonable in the circumstances. It will be able to better do so by reference to a properly implemented closure plan.

## 21.2 Negligence

Every person owes a duty of care to avoid causing harm to others or their property. Liability is decided on the basis of whether the standard of care attaching to that duty was breached and whether material damage resulted. For example, RTIO owes a duty of care to those persons for whom it is reasonably foreseeable could be harmed by the environmental effects, if any, caused by a closed site.

If a person entered a closed site and suffered harm due to unsafe conditions, RTIO may be liable for harm suffered by that person. To avoid liability for negligence, RTIO must be able to demonstrate that it took reasonable precautionary action to alleviate the risk of harm to others.

### 21.3 Breach of statutory duty

RTIO's obligations under legislation may also give rise to a statutory duty for which it will be liable if not fulfilled. Liability for breach of statutory duty is distinct from liability for negligence and RTIO may be liable for breach of statutory duty even though it may not be liable for negligence.

The types of statutory duty that courts have held to be actionable by private individuals include the duty not to cause a significant environmental impact and not to compromise industrial safety.

Generally, where a statutory provision prescribes a specific precaution for environmental protection or human safety and a duty of care exists under the general law of negligence, the duty will give rise to a private right of action under the statutory provision. In all cases, questions arise as to whether the statutory duty confers on individuals a private cause of action, whether that duty was breached and whether the duty is in fact owed to the plaintiff (i.e. the particular person bringing the action).

### 21.4 Summary of common law liability issues

A breach of relevant legislation (eg EP Act, Mining Act, MSI Act or associated regulations under these acts):

- may be evidence of a failure to comply with the duties under the MSI Act;
- may create a duty of care for the purposes of the Occupiers Liability Act;
- may be evidence of negligence or nuisance for the purposes of a common law action in negligence or nuisance; and/ or
- may give rise to a cause of action for breach of statutory duty at common law.

## 22 Rio Tinto Closure Standard (Version 4, 2012)

This closure standard was created by Rio Tinto to provide a standard to ensure that Rio Tinto managed activities are left in a condition which minimises adverse impacts on the human and natural environment. As such, it does not create legally binding obligations. However, it does set the standard that Rio Tinto aims for when decommissioning and rehabilitating its sites. Internal standards are effectively an undertaking to conduct a process in a certain manner and will provide evidence of the systems within an organisation. They can assist to establish the reasonable precautions defences under the EP Act, but also to assist avoiding potential incidents arising in the first place.

As the standard is applicable to all Rio Tinto managed activities, RTIO should ensure that it is familiar with the closure standard and follows the process for planning and implementing its closure strategy for each particular operation.

Importantly, the planning process has a number of steps including:

- developing and maintaining a knowledge base of the environment in which the operation is being developed and/or operates;

- developing and maintaining a closure strategy that promotes a consolidated multi-disciplinary approach to closure and post-closure obligations. The multi-disciplinary approach includes seeking legal advice where necessary and integrating the full range of social, environmental and economic implications that flow from closure;
- developing and maintaining a closure management plan to describe the operation's 'vision' for closure and associated preferred closure option. At a minimum, performance projections and targets must be set to cover:
  - rehabilitation;
  - bio-diversity;
  - socio-economics;
  - communications; and
  - employee relations.

Identifying and managing the legal requirements for closure are part of this planning process.

The closure standard also requires that the content of the knowledge base is periodically reviewed and updated. RTIO should ensure that it has a system in place for regularly reviewing and updating its knowledge base, including seeking additional legal advice prior to decommissioning sites. The closure plan must be fully updated at least every 5 years. This includes a review of and update of the legal position. The update process must be conducted by a multi-disciplinary team and consider future trends and possible changes in standards or expectations.

We also note that the standard directs RTIO to ensure that there are formal agreements between itself and any purchaser in the case of divestment. In this case the purchaser must agree to fulfil a minimum set of closure requirements and will close the site to an agreed set of closure standards. RTIO should also ensure that agreements regarding closure are made with the relevant government agencies and other stakeholders, as outlined in the Rio Tinto closure standards.

The closure standard lists a number of other relevant documents. We have not been provided with any of these documents and have not included them in our review. Please contact us should you wish us to review these documents and incorporate them into our advice.

# 23 Future law

We identify below other relevant legislative and policy changes or proposals that may become relevant to closure. Please advise if you require further advice in relation to these items.

## 23.1 Environmental offsets

An environmental offset is any environmentally beneficial activity undertaken to counterbalance an adverse environmental impact. Environmental offsets enable development to occur, but not at the total expense of the environment.

(a) Commonwealth

DSEWPC has released a draft *Environmental Offsets Policy* (**Policy**). The Policy provides guidance on the determination of suitable offsets during the Part

9 assessment stage of the Commonwealth environmental impact assessment process. The Policy will not be considered at the referral stage. Rather, it is proposed offsets will be used when a proposal is likely to have a significant impact on a matter of NES and despite all reasonable measures been taken to avoid or mitigate the impact, the residual impact from the proposal is still likely to have a significant impact.

The Policy proposes the use of both direct and indirect offsets, the former of these relates to those offsets that amount to on the ground protection, while the later refers to a range of measures including increased knowledge and understanding. Importantly, the Policy also outlines in detail:

- factors to be taken into account when assessing whether an offset is necessary; and
- factors to be taken into account when assessing if a proposed offset is a suitable offset.

It is likely that RTIO proposals will be subject to offset considerations when being evaluated under the impact assessment process.

(b) Western Australia

EPA Position Statement No 9 expresses the need for environmental offsets to have a long-lasting benefit. However, the requirements and guidance set out are uncertain in terms of cost and timeframe. The State Government's position on offsets is very general in its terms and its application is very project specific.

Where relevant, future expansion plans requiring EP Act Part IV approval may have a condition imposed relating to offsets. Offsets will likely have a life beyond operations. That is, depending on the nature of the offset, liability for ongoing maintenance of the offset may remain with RTIO post relinquishment of mining tenements and therefore impact on closure.

## 23.2 Closure standards

We note that the MOU between the DoIR and EPA in relation to the referral of onshore mineral exploration and mining development proposals requires referral documents to specify closure standards in accordance with the ANZMEC/MCA Strategic Framework for Mine Closure. In particular, that mine closure issues should be considered before mining commences and that mine planning and mine closure are integrated.

Future approvals will therefore entrench closure requirements (and standards) at least to the extent required by the evolving closure standards.

## 23.3 Proposed changes to the EPBC Act

The Federal Government has recently published a document entitled, *Reforming national environmental law: An overview*. The publication indicates several possible amendments to the EPBC Act, the two most significant are:

- introducing Regional Environmental Plans and Strategic Assessments to allow broad classes of actions to bypass the Commonwealth Impact Assessment process; and
- introducing 'ecosystems of national significance' and 'vulnerable ecological communities' as matters of national environmental significance.

These changes are expected to be tabled in Parliament in 2012.

### 23.4 Water Act

It is likely that many of the obligations contained in the *Rights in Water and Irrigation Act 1914* will soon be incorporated into the proposed *Water Services Bill 2011*. However, it is unlikely that any of RTIO's positive obligations will change as a result of the new legislation.

## 24 Regulators

### 24.1 General statutory obligations

(a) Western Australia

(1) The Environmental Protection Authority and the Office of the EPA are responsible for setting offsets and auditing closure conditions approvals under Part IV of the EP Act.

(2) The Department of Environment and Conservation is responsible for administering the:

- *Environmental Protection Act 1986;*
- *Environmental Protection (Controlled Waste) Regulations 2004;*
- *Environmental Protection (Unauthorised Discharges) Regulations 2004;*
- *Contaminated Sites Act 2003;*
- *Conservation and Land Management Act 1984;* and
- *Wildlife Conservation Act 1950.*

In addition, the Department of Environment and Conservation also administers all licences, approvals, notices and permits granted under the *Environmental Protection Act 1986.*

(3) The Department of Mines and Petroleum is responsible for administering the:

- *Mining Act 1978;* and
- *Mines Safety and Inspection Act 1995.*

(4) The Department of the Attorney General is responsible for administering the:

- *Occupiers' Liability Act 1985;*
- *Criminal Code Compilation Act 1913;*
- *Aboriginal Affairs Planning Authority Act 1972;* and
- AH Act.

(5) The Department of Regional Development and Lands is responsible for administering the *Parks and Reserves Act 1895.*

(6) The Department of Water is responsible for administering the *Rights in Water and Irrigation Act 1914.*

(7) The Department of State Development is responsible for administering State Agreements.

(b) Commonwealth

(1) The Department of Sustainability, Environment, Water, Population and Communities is responsible for administering the:

- *Environment Protection and Biodiversity Conservation Act 1999*; and
- *Aboriginal and Torres Strait Islander Heritage Protection Act 1984.*

(2) The Department of the Attorney General is responsible for the administration of the *Native Title Act 1993.*

## 24.2 Mine Closure Plans

From 1 July 2011, the EPA will generally not assess mine closure as part of its environmental impact assessment of mining proposals under the Environmental *Protection Act 1986*, where they are subject to the *Mining Act 1978*. The EPA will only assess mine closure in these circumstances if it considers there are particular issues which pose a high environmental risk or where the proponent request parallel assessment. The EPA will consult with DMP before making any such decision.

For mining projects not subject to the *Mining Act 1978* (such as pre- 1899 title or minerals-to-owner tenure, Hampton locations or State Agreement Act projects) the EPA will normally assess mine closure as part of its EIA process. This is likely to be the case for most of RTIO's major Pilbara operations. As a matter of course the EPA will consult with DMP on these assessments.

Where the EPA does assess mine closure, it is likely an approval condition will be applied requiring preparation of a MCP. In this circumstance, it is stated in the Guidelines that compliance monitoring of this approval condition may be delegated to the DMP. However, legally the DMP has no jurisdiction to enforce Part IV approval conditions.

As such the principle regulator for MCPs is the DMP but the Guidelines state that the approval processes for MCPs will often require advice or endorsement from other environmental regulators.

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# LAORS Approval / Agreement and

**Type: Approval / Agreement, Site Name: West Angelas, Project Name: All, Discipline: All, Approval Type: All, Regulatory Body: All, Status: All, Closure Obligation: Yes, Enviroment Reporting Requirement: No, Included Historic: No, Phase Regulatory: All, Phase RTIO: All, Document Details: No**

| Site Name | Project Name | Type | Expiry Date | Title | Reference No | Requirement | Approval Type | Regulatory Body | Resp Person | Deleg / App Person | Phase Regul. | Phase RTIO | Status | Cl Obl | Env Rep Req | Enviro Report Type | First Report Due Date | Rep Freq |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| West Angelas | West Angelas Operations | Approval | 28/05/2016 | DEC Licence L7774/2000/6 | Tyre Storage and Disposal - 12 | The licensee shall ensure that the following criteria is met when tyres are stored and buried at the premises: - the quantity of used tyres stored at the premises shall not exceed 100 at any one time - the tyres are buried as soon as practicable after placement in the waste dumps - a minimum depth of 100mm of soil cover is maintained over the buried tyres following disposal - batches of tyres are separated from each other by at least 100 mm of soil with each batch consisting of not more that 1000 whole tyres or 40 cubic metres of tyre pieces - tyres are buried with a minimum cover to tyre ratio of 4 to 1. That is 4m3 of soil or rubble cover to 1m3 of tyre waste - tyres are buried under a final cover of not less than 2 metres of soil | EP Act Part V | Department of Environment Regulation (DER) | Manager Mining | Development Superintendent | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | AACR AER | 30/04/2013 | Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Purpose - 1.1 | This Plan will be extensively updated and developed at least six months prior to the decommissioning of the West Angelas Project. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Objectives - 1.3 | The objectives of the Decommissioning and Rehabilitation Management Plan are: - To ensure that progressive rehabilitation of disturbed areas renders them safe and stable and encourages the re-establishment of self-sustaining vegetation, and - To ensure that rehabilitation of all disturbed areas is to a suitable standard. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Robe's HSE Management System - 2.2 | Further details of Robe's HSE Management System and RQMS are contained in the West Angelas Project Environmental Management Program. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Legislative Requirements - Robe's ERMP Commitments - 2.4.2 | Robe made the following commitment relevant to this Plan in the West Angelas ERMP: An Environmental Management Plan would be prepared which would include, but not be limited to consideration of: - Rehabilitation and revegetation of disturbed areas. This Plan has been prepared to meet this commitment. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Construction Objectives - 3.1 | The objectives for the construction phase are as follows: - To ensure that disturbance of areas not actually mined or required for infrastructure is minimised, - To ensure that vegetative material is removed and stockpiled correctly, and - To ensure that seed bearing topsoil is removed and stockpiled correctly. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Construction Rehabilitation Areas - West Angelas Minesite - 3.2.1 | Progressive rehabilitation will occur throughout the life of the West Angelas Project with final rehabilitation occurring after decommissioning. Cleared or disturbed areas to be rehabilitated include, but are not limited to: - exploration gridlines, - drill pads, - access roads, - lay down areas, - bore locations, and - other cleared areas. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Construction Rehabilitation Areas - West Angelas Railway - 3.2.2 | Progressive rehabilitation of cleared areas associated with the railway will also occur throughout the life of the project, though primarily in the Post Construction phase. Final rehabilitation will occur after decommissioning. Areas to be rehabilitated include but are not limited to: - Borrow pits, - Construction camp sites, - Bore locations, and - Disused access roads and tracks. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Construction Management Actions - Minimisation Of Areas Disturbed - 3.3.1 | (1) Disturbance of areas not actually mined or required for infrastructure will be minimised. Limits of clearing will be demarcated in the field. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Construction Management Actions - Vegetation Stockpiling - 3.3.1 | (2) Cleared vegetation will be stockpiled for respreading either directly or at a later date to minimise erosion and aid in rehabilitation. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Construction Management Actions - Vegetation Stockpiling - 3.3.1 | (3) Cleared vegetation will not be burnt as this will destroy seed, organic and biological content that is beneficial for successful rehabilitation. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Construction Management Actions - Vegetation Stockpiling - 3.3.1 | (4) Vegetative material will be stockpiled longitudinally along the sides of the cleared area and left in neat windrows for rehabilitation. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |

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| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Construction Management Actions- Topsoil Stockpiling - 3.3.3 | (5) The top 100 mm part of the soil profile, called seed bearing topsoil, (can range from loams to rocky material) will be removed using a dozer or front end loader. Using a grader for this operation tends to pulverise the soil structure, due to the many passes required to move the material and reduces its potential for successful rehabilitation. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Construction Management Actions- Topsoil Stockpiling - 3.3.3 | (6) Topsoil will not be stored in large heaps. Once soils are disturbed, biological and composting processes are activated which slowly destroy both the seed bank and biological content. Low mounds of no more than 1.5 metres high will be used. Topsoil stockpile locations will be recorded and signposted to prevent them from being used for other purposes or disturbed by other activities. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | | | |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Construction Management Actions- Topsoil Stockpiling - 3.3.3 | (7) Stockpiles of topsoil will be used as soon as possible. Where it is known that the material will be stockpiled for long periods, i.e.. a number of years, the surface profile will be roughly spread and ripped to contour, promoting germination. This will encourage plant establishment and the setting of seed to maintain the seed bank. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | | | |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Construction Management Actions- Topsoil Stockpiling - 3.3.3 | (8) Topsoil will be stored where it will not be affected during construction activities, and away from areas of surface water flow. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | | | |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Construction Management Actions- Topsoil Stockpiling - 3.3.3 | (9) In pursuing best practice techniques, soils will not be stripped when they are wet and waterlogged where possible, as this can lead to compaction and loss of soil structure. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | | | |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Construction Management Actions- Topsoil Stockpiling - 3.3.3 | (10) The risk of topsoil stockpiles becoming a source of airborne dust will be minimised though an initial application of water where practicable. This will reduce dust during the establishment of the stockpile, as well as encouraging the growth of vegetation and the formation of a crust which retards future dusting. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | | | |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Construction Performance Indicators - 3.4 | Robe's performance will be reviewed against the following indicators: - Minimisation of vegetation cleared, - Correct storage of topsoil, and - Correct storage of vegetation overburden | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Construction Monitoring - 3.5 | The progress of all management actions will be monitored using the Robe Action Management System (RAMS), and - An environmental officer will inspect all cleared areas to ensure that topsoil and vegetation overburden are being stockpiled as per the guidelines in this plan. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |

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| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Construction Timing-Minimisation Of Areas Disturbed - 3.6.1 | Clearing of areas not directly used for mining will be kept to a minimum at all times throughout the life of the West Angelas Project. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Construction Timing-Vegetation Stockpiling - 3.6.2 | Clearing of vegetation and stockpiling of the vegetative material will occur during the construction phase. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Construction Timing-Topsoil Stockpiling - 3.6.3 | Topsoil stockpiling will occur throughout the construction phase. Earthworks will be carried out when the soil is dry enough to move. Earthworks will not be attempted when the soil is wet and waterlogged. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Construction Responsibility - 3.7 | Robe's management will utilise the Robe Action Management System (RAMS) to delegate responsibilities to line management and track progress of management actions. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Post Construction Objectives - 4.1 | The objectives for the post–construction phase are as follows: - Prevent evaporation of groundwater brought to the surface by capillary rise in the soil cover, - Minimise the long term visual impact by reshaping the land so it is compatible with the adjacent landscapes, and - Encourage the re-establishment of self-sustaining ecosystems | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Post Construction Areas to be Rehabilitated - 4.2 | Refer to section 4.2. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Post Construction Management Actions - Progressive Rehabilitation - 4.3.1 | (11) Disturbed areas will be progressively rehabilitated as soon as practicable at the end of ground disturbing activities. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | | | |

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| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Post Construction Management Actions - Batters and Slopes - 4.3.2 | (12) Waste dump or steep slopes will be battered until they are characteristic of the natural slope of the area. Batter slopes will be formed to comply with DME guidelines (DME, 1996) with slopes of no greater than 200. This will promote stabilisation and water harvesting to ensure vegetation establishment. Where possible waste dumps will be constructed to have a rounded footprint and shape blended into existing hill slopes and the landscape generally. Borrow pit slopes will be battered to a maximum slope of 1 in 3. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Post Construction Management Actions - Batters and Slopes - 4.3.2 | (13) Windrows will be used along the toe and along the crest of all slopes to prevent water entering onto slopes and causing erosion down the face. Bottom windrows will help hold any erosion that may occur on the slope face." | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | | | |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Post Construction Management Actions - Back-Filling of Mine Pits - 4.3.3 | (14) Mine pits will be back-filled so the groundwater table is below the surface. Groundwater loss through capillary action and subsequent evaporation will then be negligible following completion of mining. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Post Construction Management Actions - Topsoil Application - 4.3.4 | (15) The recovery and use of seed bearing material or topsoil is one of the most important elements for successful rehabilitation. All vegetation overburden and where possible the top 100 mm of soil will be re-spread over disturbed surfaces to act as a mulch, seed trap and store, as protection from erosion and to inhibit access. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Post Construction Management Actions - Topsoil Application - 4.3.4 | (16) Where practical topsoil will be used immediately for rehabilitation purposes to achieve optimum results. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | | | |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Post Construction Management Actions - Ripping - 4.3.5 | (17) Ripping via the use of a triple tyne will be used where practicable in areas that have a hardened or compacted soil surface (such as heavily used access tracks) to break compaction. This will foster water retention, water management and create seed trapping niches. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |

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| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Post Construction Management Actions - Ripping - 4.3.5 | (18) All ripping will be carried out using a triple tyne bulldozer or other suitable equipment to a depth of no more than 500 mm (Robe, 1997). Ripping will be along the contour with 1 m between rip lines to prevent water movement down slopes and ensure effective water penetration for plant use. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | | | |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Post Construction Management Actions - Ripping - 4.3.5 | (19) Ripped ground will not be driven over. Ripping will start at the furthest point and finish at the exit point, and be left as rough as possible. This roughness helps to discourage people from driving into pits and damaging rehabilitation establishment. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | | | |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Post Construction Management Actions - Seeding - 4.3.6 | (20) Seed will be collected from as many local native species as possible to provide a blend of up to 40 different species, ranging from tree species down to ground covers. Emphasis will be placed on spinifex (climax species) and nitrogen fixing legume species (wattles). | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Post Construction Management Actions - Seeding - 4.3.6 | (21) All seeding will be undertaken in a manner so as to reduce the number of seeds lost to deep burial. Current practices are seeding by hand. Should future developed technology improve this process, the use of such technology will be considered. The rate of seed applied will depend on the amount of topsoil applied. Rates will generally be between 5 and 10 kg/ha. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | | | |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Post Construction Management Actions - Weed Control - 4.3.7 | (22) If weeds are found to be present in areas being rehabilitated, weed control will be undertaken in a manner which is consistent with the Weed Management Plan. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Post Construction Management Actions - Fire Protection - 4.3.8 | (23) Wildfires can significantly effect rehabilitation efforts. Robe will review existing fire control/suppression plans to ensure they are adequate. Fire control measures such as developing fire breaks and low fuel load areas will be developed. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Post Construction Management Actions - Signage - 4.3.9 | (24) Appropriate signage will be erected to advise where ever rehabilitation is in progress and that personnel are not permitted to enter the area. Access, if granted, will only be permitted by foot. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |

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| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Post Construction Management Actions - Development of Completion Criteria - 4.3.10 | (25) The rehabilitation programme will be based on post-mining land use objectives established by baseline study and consultation during the pre-mining and early operational phases of the project. At the conclusion of the project Robe together with representatives of relevant decision making authorities will determine whether the land use objectives have been met or will be met without further management intervention. Objective completion criteria will be established to facilitate the release of Robe from the environmental obligations. The nature of the completion criteria will depend on the type of end-use which has been selected and the environmental factors in the project area. Completion criteria may be as diverse as engineering specifications for structures, water quality standards for runoff or leachate, erosion/sedimentation rates, the return of specific plants, animals or biotic communities or the establishment of a self-perpetuating and resilient vegetative cover. Completion criteria to be developed will be site and location specific. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Post Construction Performance Indicators - 4.4 | Robe's performance will be reviewed against the following indicators: - Progressive rehabilitation of suitable areas, -Waste dump sides and steep slopes will be to a maximum batter of 200 - Borrow pit slopes will be battered to a maximum slope of 1 in 3. - Re-use of all vegetation overburden and 100 mm of topsoil, - Ripping to a depth of no more than 500 mm, - Degree of weed infestation, - Development of fire breaks and low fuel load areas,- Signs placed at appropriate locations, and - Development of completion criteria | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Post Construction Monitoring - 4.5 | A program to monitor the success of rehabilitation and the fulfilment of completion criteria will be developed in consultation with relevant government agencies prior to construction. - The progress of all management actions will be monitored using the Robe Action Management System (RAMS). - Monitoring will be undertaken systematically at regular intervals such as the first year after rehabilitation and again in years 2, 5 and 10. In addition, annual visual and photographic assessments will be made. - Standard sampling techniques will be adopted, including the establishment of photographic records. Transects will be used to quantify the establishment of vegetation, while in some areas, profile gauges and/or erosional transects will be used to measure rates of erosion in susceptible areas. The results of monitoring in rehabilitated areas will be compared with those recorded in control sites. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Post Construction Timing - Progressive Rehabilitation - 4.6.1 | Progressive rehabilitation will be carried out as soon as practical (after ground disturbing activities have finished) during all phases of the project. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Post Construction Timing - Batters and Slopes - 4.6.2 | Battering of steep slopes will be carried out as soon as practical. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Post Construction Timing - Back-Filling of Mine Pits - 4.6.3 | Back-filling of mine pits will occur as soon as practical | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | | | |

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| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Post Construction Timing - Topsoil Application - 4.6.4 | Earthworks will be carried out when the soil is dry enough to move. Earthworks will not be attempted when the soil is wet and waterlogged. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Post Construction Timing - Ripping - 4.6.5 | Earthworks will not be undertaken during wet or boggy conditions. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Post Construction Timing - Seeding - 4.6.6 | Where possible provenance seed will be used for rehabilitation works. The area for collecting provenance seeds for rehabilitation will be confined to the Hamersley Range between Tom Price and Paraburdoo in the west and Newman in the east. Seed will not be sourced from desert regions to the east of Newman. Where provenance seed is limited CALM will be consulted regarding suitability of alternative sources of seed. Seeding of rehabilitation areas will be carried out as soon as practicable following the completion of earthworks. Where practicable, all works will be completed prior to the commencement of summer rains. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Post Construction Timing - Weed Control - 4.6.7 | Refer to the Weed Management Plan. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Post Construction Timing - Fire Protection - 4.6.8 | Fire control techniques will be enforced at all times during the life of the West Angelas Project. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Post Construction Timing - Signage - 4.6.9 | Appropriate signage will be erected as soon as rehabilitation works begin. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |

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| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Post Construction Timing - Development of Completion Criteria - 4.6.10 | These will be defined during the operational phase before decommissioning. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Post Construction Responsibility - 4.7 | Robe's management will utilise the Robe Action Management System (RAMS) to delegate responsibilities to line management and track progress of management actions. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Decommissioning - West Angelas Minesite - 5.1 | Given the strategic value of the WAP and the presence of a number of other iron ore deposits Robe expects to retain ownership of this facility long after Deposits A and B are exhausted. When it is required a decommissioning plan for the minesite will be developed no later than six months before closure of the facility. The plan will be developed in consultation with relevant stakeholders. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Pre-Closure | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Decommissioning - West Angelas Railway - 5.2 | Decommissioning of infrastructure areas required for the construction phase of the West Angelas Railway will be as follows: - Groundwater bores will not be totally decommissioned but capped and locked for potential future use; - Drill pads and access tracks will be rehabilitated; - Borrow pits will be progressively rehabilitated after they have finished being used; - After construction is complete, the quarry will be maintained in case there is a need for rail ballast for future maintenance activities. It will be decommissioned and rehabilitated at the end of the operational life of the mine or as determined in consultation with relevant government agencies. Where possible worked out areas of the quarry will be progressively rehabilitated; - Temporary access roads and tracks to borrow pits, camps and work sites will be rehabilitated. - Camps and their associated infrastructure will be decommissioned and the areas rehabilitated after they have finished being used. - The rail quarry access road and roads to radio communication towers will be maintained during the operational life of the mine and decommissioned and rehabilitated at the end of the operational life of the mine; - Should it be required appropriate procedures for breaching the rail formation, including the rail access road, following decommissioning will be developed in conjunction with the relevant stakeholders no later than six months before decommissioning. Six months prior to the decommissioning of the West Angelas Project, discussion will be held with the Department of Resources Development on the future use and strategic value of the railway line prior to the completion of a detailed decommissioning strategy. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Pre-Closure | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Decommissioning - Cape Lambert Port - 5.3 | Under the Robe State Agreement Act, the Cape Lambert Port facilities will become the property of the State when they are no longer in use. If required, a decommissioning plan for Cape Lambert will be developed no later than one year before closure of the facility. The plan will be developed in consultation with stakeholders (Government, Cossack Pearls, community etc). | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Pre-Closure | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |

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| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Decommissioning - Contaminated Sites - 5.4 | Identification and remediation of contaminated areas, including provision of evidence of notification to relevant statutory authorities will be undertaken during the decommissioning phase | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Pre-Closure | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Auditing - Robe internal auditing - 6.1 | Robe will conduct an annual compliance audit. The results will be reported on in the Annual and Triennial Report which is submitted to DRD. The action items generated by this audit will be managed within Robe's Action Management System (RAMS). | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Auditing - Review by Joint Venture Participants - 6.2 | An informal review of Robe's operations will be undertaken by an external consultant as part of the process of generating North Limited's Public Environment, Safety and Health Annual Report. Robe's progress against previous action items will be measured and next years action items will be generated. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Auditing - Audits by Government Agencies - Compliance Auditing - 6.3.1 | The Performance and Compliance reports will refer to Ministerial conditions as detailed in the DEP Audit Table for Ministers Statement 514. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Auditing - Audits by Government Agencies - 6.3 | Management personnel from Department of Resources Development, Department of Conservation and Land Management, Department of Environmental Protection, Department of Minerals and Energy and Waters and Rivers Commission may audit the site on a three yearly basis in conjunction with the Triennial report review. Action items generated from this audit are managed within RAMS. In addition the DEP Audit branch will check compliance with conditions in the Ministerial statement under part IV of the Environmental Protection Act. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Reporting - Robe Internal reporting - 7.1 | All employees and contractors will be required to report environmental near misses, incidents and hazards via their supervisor. The actions resulting from these reports will be managed through the existing Robe Action Management System (RAMS). | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C<br>One off | 01/01/1900 | 6 Year<br>Annual<br>Other |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Reporting - Environmental Reporting - 7.2 | All environmental reporting required under this Plan will be detailed in the Annual and Triennial environmental reports required under the Robe State Agreement Act which are submitted to the Department of Resource Development. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P | 01/01/1900 | 6 Year |

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| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Reporting - Environmental Reporting - 7.2 | Additionally, Robe will provide relevant data and progress reports, which will be incorporated into North's Annual Environment, Safety and Health Annual Report | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | | | |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Reporting - Reporting Government Agencies - 7.3 | The performance of this Plan will be reported in future Annual and Triennial reports that will be submitted to the Department of Resource Development as required under the Robe State Agreement Act. Where appropriate, monitoring data will be summarised and/or submitted in full in an appendix. Any programme refinements will also be discussed in these reports. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Reporting - Reporting Government Agencies - Performance Review - 7.3.1 | [MS-514] condition 14 further describes the review scope which is the objectives contained in EPA Bulletin 924, ERMP commitments and those arising from the fulfilment of conditions and procedures in the Minister's statement (dated 28 June 1999), EMS environmental management targets, EMP's and environmental performance indicators (refer to EPA (1999) for full description). The reporting of the required performance review will be contained in the applicable future Annual and Triennial reports as required under the Robe State Agreement Act. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Reporting - Reporting Government Agencies - Reporting of Non-Compliance Events - 7.3.2 | Non-compliance or emergency events will be reported as per the requirements of relevant licences (eg. DEP and WRC).<br>Robe will be responsible for ensuring the timely completion of the report and it's content and presentation are to the satisfaction of the DRD. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C One off | 01/01/1900 | 6 Year Annual Other |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Reporting - Reporting Government Agencies - Reporting of Non-Compliance Events - 7.3.2 | Significant hazards and/or incidents are reported to North Limited as the project manager and the Joint Venture Participants Group. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | | | |
| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Management Programme Summary - 8 | A table summarising the objectives, actions, timing and performance indicators is set out in this section. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |

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| West Angelas | West Angelas Operations | Approval | | Decommissioning and Rehabilitation Management Plan | Appendix 1 - Summary of Management Actions Relating to Ministerial Conditions | Appendix 1 sets out a summary of the management actions and how these relate to the conditions of the Ministerial statement. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |
| West Angelas | West Angelas Operations | Approval | | Drainage Diversion Management Plan | Decommissioning - Progressive Rehabilitation - 7.1 | Whilst the drains are designed and constructed as permanent structures, progressive rehabilitation will be undertaken wherever possible. Post construction rehabilitation will be undertaken to establish local native plant cover over areas of works and sides of embankments. The rehabilitation will aim to stabilise the structure surface and minimise localised erosion. Any rehabilitation activity will be undertaken in a manner which is consistent with the Minesite Decommissioning and Rehabilitation Management Plan. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |
| West Angelas | West Angelas Operations | Approval | | Drainage Diversion Management Plan | Decommissioning - Decommissioning Concept - 7.2 | As the diversion channels are permanent structures they will remain in place after decommissioning. Any decommissioning activity will be undertaken in a manner which is consistent with the Minesite Decommissioning and Rehabilitation Management Plan. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Manager Water Operations and Closure | Closure Specialist | Pre-Closure | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |
| West Angelas | West Angelas Operations | Approval | | Environmental Management Plan - Minesite | Construction Management Actions - Vegetation - 5.4.3 | In recognition of the potential impacts it is proposed that: (8) Construction will be supervised to ensure it meets the design. (9) Limits of clearing will be demarcated in the field by flagging, signage or temporary fencing as appropriate. Vegetation clearing will be undertaken within the surveyed and pegged areas and limited to the minimum required. (10) A vegetation monitoring program will be established downstream of Deposit B (refer to WAP Drainage Diversion MP). (11) Topsoil and cleared vegetation will be cleared from all areas where infrastructure are located and stockpiled separately for later reuse (refer to Rehabilitation and Decommissioning Management Plan for details). (12) Vegetation clearing will be undertaken in compliance with Appendix 5. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Environment Superintendent | SEA | Construction | Implementation (Construction) | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |
| West Angelas | West Angelas Operations | Approval | | Environmental Management Plan - Minesite | Construction Management Actions - Fauna - 5.4.4 | In recognition of the potential impacts it is proposed that: (13) The Ghost Bat Management Plan will be implemented (refer to WAP Ghost Bat Management Plan). (14) Any disturbed areas available for rehabilitation will be rehabilitated prior to the commencement of the operation phase. (15) Pits will be fenced or bunded to deter access by larger animals such as kangaroos. (16) Drill hole capping will incorporate best practice methodology for permanent sealing below ground level as detailed in Robes Exploration Environmental Management System. Drill holes will be regularly monitored to ensure the cap remains in place. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Environment Superintendent | SEA | Construction | Implementation (Construction) | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |
| West Angelas | West Angelas Operations | Approval | | Environmental Management Plan - Minesite | Post Construction Objectives - 6.1 | The objectives of the Minesite Environmental Management Plan during the post construction phase are: (1)To operate the WAP in a manner which minimises erosion, sediment transport and turbidity, (2)To operate the WAP in a manner which minimises the adverse impacts on surface water quality and flows, (3)To operate the WAP in a manner which minimises the adverse impacts on groundwater quality and resource volume, (4)To operate the WAP in a manner which minimises the impact on vegetation (including Declared Rare and Priority Flora), (5)To operate WAP in a manner which minimises dust generation; (6)To operate the WAP in a manner which minimises the impact on fauna, (7)To implement appropriate and effective waste management; (8)To construct waste dumps in a manner which maximises harmony with the landscape, (9)To undertake all activities in a manner which is consistent with the other relevant Management Plans, and (10)To where possible, undertake progressive revegetation and rehabilitation. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Environment Superintendent | SEA | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | | | |

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| West Angelas | West Angelas Operations | Approval | | Environmental Management Plan - Minesite | Post Construction Management Actions - Vegetation - 6.4.3 | In recognition of the potential impacts it is proposed that: (5) Progressive rehabilitation of disturbed areas will be undertaken as soon as possible. (6) Topsoil will be used to rehabilitated disturbed areas as required (refer Decommissioning and Rehabilitation Management Plan Vegetation).(7) Topsoil stockpiles will be managed to maintain topsoil values (refer to WAP Decommissioning and Rehabilitation Management Plan for details). | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Environment Superintendent | SEA | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Environmental Management Plan - Minesite | Post Construction Management Actions - Fauna - 6.4.4 | In recognition of the potential impacts it is proposed that: (8) Where possible, future clearing will be restricted to existing disturbance corridors. (9) The Ghost Bat Management Plan will be implemented (refer to WAP Ghost Bat Management Plan). (10) Where possible, any disturbed areas available for rehabilitation will be rehabilitated prior to the decommissioning phase. (11) Pits will be fenced or bunded to deter access by larger animals such as kangaroos. (12) Drill holes will be regularly monitored to ensure the cap remains in place. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Environment Superintendent | SEA | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Environmental Management Plan - Minesite | Post Construction Management Actions - Groundwater and Surface Water Quality - 6.4.5 | Despite the negligible risk and impact of contamination the prevention of contaminants entering the environment is Robe's existing and preferred approach. In recognition of the potential impacts it is proposed that: (14) All surface water run-off collected by the mine pits will be discharged via settlement ponds. Where possible this water will be reused or if the volume exceeds requirements it will be discharged into natural channels (in accordance with the Pannawonica design). (15) When waste dumps are located near drainage channels, the dumps will be monitored and rock armoured if necessary to prevent scouring and erosion (Robe, 1992). (16) Waste dumps will be constructed in accordance with Department of Minerals and Energy guidelines (refer to WAP Minesite Rehabilitation and Decommissioning Plan). (17) All chemicals will be stored on site in accordance with Dangerous Goods Regulations. (18) Wastewater treatment plants will be installed to treat wastewater from workshops, toilet facilities and other potential pollution sources as required. (19) Visual inspections will be undertaken between October and April to ensure that the diversions are functioning as per design. (20) Water quality samples will be taken if potential contaminants are believed to have reached diversion channels and water sampling will be undertaken in a manner which ensures sample integrity. (21) Application of Robe's existing management measures at West Angelas to minimise the possibility of contaminants entering the environment during the operation. For example: (a) Equipment servicing will take place in workshops wherever possible, and (b) Field servicing will be undertaken in a manner which meets best practice field servicing guidelines. (22) In accordance with Robe's existing spill response procedures chemical (including hydrocarbon) spills will be cleaned up as soon as practicable and contaminated soil removed and appropriately disposed of to prevent off site transport. - All DEP and WRC licence monitoring and reporting requirements will be complied with, (23) An investigation will be undertaken to determine the required characteristics of the backfill layer to prevent capillary rise. The investigation will also consider the predicted settlement rates of the backfilled material. (24) Ensure that all employees and contractors comply with the sites environmental management requirement to manage chemicals in a manner which prevents them from contaminating the environment.(25) All employees and contractors will be required to attend an Health, Safety and Environmental induction, which includes a spill prevention and response section. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Environment Superintendent | SEA | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | | | |
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| West Angelas | West Angelas Operations | Approval | | Environmental Management Plan - Minesite | Post Construction Management Actions - Dust - 6.4.7 | In recognition of the potential impacts it is proposed that: (28) All activities will be undertaken to minimise where practical dust generation. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Environment Superintendent | SEA | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P | 01/01/1900 | 6 Year |

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| West Angelas | West Angelas Operations | Approval | | Environmental Management Plan - Minesite | Post Construction Management Actions - Weeds - 6.4.8 | In recognition of the potential impacts it is proposed that: (29) All activities will be undertaken to minimise the spread of weeds (refer WAP Weed Management Plan). | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Environment Superintendent | SEA | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Environmental Management Plan - Minesite | Post Construction Management Actions - Visual Amenity - 6.4.10 | In recognition of the potential impacts it is proposed that: (32) Waste dumps will be constructed to have a rounded footprint and where possible, blend each dump into existing hill slopes. Construction will be in accordance with DME regulations. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Environment Superintendent | SEA | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Environmental Management Plan - Minesite | Decommissioning - Progressive Rehabilitation - 7.1 | Progressive rehabilitation will be undertaken wherever possible. Rehabilitation will be undertaken to minimise erosion potential and to re establish local native plant cover on all areas. Any rehabilitation activity will be undertaken in a manner which is consistent with the Minesite Decommissioning and Rehabilitation Management Plan. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Rehabilitation Specialist | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Environmental Management Plan - Minesite | Decommissioning - Decommissioning Concept - 7.1 | Given the strategic value of the WAP and the presence of a number of other iron ore deposits Robe expects to retain ownership of this facility long after Deposits A and B are exhausted. When it is required a decommissioning plan for Cape Lambert will be developed no later than one year before closure of the facility. The plan will be developed in consultation with stakeholders (Government, pastoralists, community etc). Any decommissioning activity will be undertaken in a manner which is consistent with the Minesite Decommissioning and Rehabilitation Management Plan. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Closure Specialist | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Environmental Management Plan - Minesite | Appendix 5 - Vegetation Clearance Procedures | Appendix 5 details the vegetation clearing procedures to apply pursuant to section 5 of this plan, including in table A2.1 a spill clean up and reporting guideline, including the following rehabilitation requirements: - During any earthworks: • Clearing of slopes leading to watercourses will be delayed until construction at the crossing is imminent, therefore minimising erosion and sedimentation risks.• Any cleared vegetation should be stockpiled for re-spreading either directly or at a later date to minimise erosion and aid in rehabilitation. • Do not burn cleared vegetation. - For earthworks where excavations are required, eg. infrastructure, borrow pits: • After vegetation has been cleared the top 100mm profile of soil should be removed and stockpiled separately from the vegetation. • Do not store top soil in large heaps. Once soils are disturbed, biological and composting processes are activated which slowly destroy both the seed bank and biological content. Low mounds of no more than 1.5 metres high are recommended. • Plan to use stockpiles of top soil as soon as possible. Where it is known that the material will be stockpiled for long periods, i.e.. a number of years, the surface profile can be roughly spread and ripped to contour, promoting germination. This will encourage plant establishment and the setting of seed to enrich the seed bank.• Store top soil and cleared vegetation where it will not be affected during construction activities, and away from areas of surface water flow. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Environment Superintendent | SEA | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |

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| West Angelas | West Angelas Operations | Approval | 22/06/2030 | General Purpose Lease 47/1235 | 1 | Survey | Mining Act | Department of Mines & Petroleum (DMP) | Registered Manager | Technical Services Superintendent | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | 22/06/2030 | General Purpose Lease 47/1235 | 11 | All topsoil and vegetation being removed ahead of all mining operations and being stockpiled appropriately for later respreading or immediately respread as rehabilitation progresses. | Mining Act | Department of Mines & Petroleum (DMP) | Registered Manager | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | 22/06/2030 | General Purpose Lease 47/1235 | 12 | At the completion of operations, all buildings and structures being removed from site or demolished and buried to the satisfaction of the Executive Director, Environment Division, DMP. | Mining Act | Department of Mines & Petroleum (DMP) | Registered Manager | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | 22/06/2030 | General Purpose Lease 47/1235 | 13 | All rubbish and scrap is to be progressively disposed of in a suitable manner. | Mining Act | Department of Mines & Petroleum (DMP) | Registered Manager | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | 22/06/2030 | General Purpose Lease 47/1235 | 15 | At the completion of operations or progressively where possible, all access roads and other disturbed areas being covered with topsoil, deep ripped and revegetated with local native grasses, shrubs and trees to the satisfaction of the Executive Director, Environment Division, DMP. | Mining Act | Department of Mines & Petroleum (DMP) | Registered Manager | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | 22/06/2030 | General Purpose Lease 47/1236 | 12 | All topsoil and vegetation being removed ahead of all mining operations and being stockpiled appropriately for later respreading or immediately respread as rehabilitation progresses. | Mining Act | Department of Mines & Petroleum (DMP) | Registered Manager | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | 22/06/2030 | General Purpose Lease 47/1236 | 13 | At the completion of operations, all buildings and structures being removed from site or demolished and buried to the satisfaction of the Executive Director, Environment Division, DMP. | Mining Act | Department of Mines & Petroleum (DMP) | Registered Manager | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | 22/06/2030 | General Purpose Lease 47/1236 | 14 | All rubbish and scrap is to be progressively disposed of in a suitable manner. | Mining Act | Department of Mines & Petroleum (DMP) | Registered Manager | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | 22/06/2030 | General Purpose Lease 47/1236 | 15 | The lessee taking all reasonable measures to prevent or minimise the generation of dust from all materials handling operations, stockpiles, open areas and transport activities. | Mining Act | Department of Mines & Petroleum (DMP) | Registered Manager | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | 22/06/2030 | General Purpose Lease 47/1236 | 16 | At the completion of operations or progressively where possible, all access roads and other disturbed areas being covered with topsoil, deep ripped and revegetated with local native grasses, shrubs and trees to the satisfaction of the Executive Director, Environment Division, DMP. | Mining Act | Department of Mines & Petroleum (DMP) | Registered Manager | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |

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| West Angelas | West Angelas Operations | Approval | | Greenhouse Gas Emission Management Plan | Construction Management Actions - Abatement Actions - 4.1.4.1 | Robe will undertake the following management actions: (1) Robe's Greenhouse Challenge Coordinator will coordinate Robe's Greenhouse Challenge response. (2) Energy efficient design or equipment modifications (abatement actions) will be considered for implementation, subject to Robe approval procedures. (3) To ensure abatement actions are dynamic and not just reviewed annually, progress on existing actions and any new action will be recorded and monitored RAMS. (4) As part of the commitment to the Greenhouse Challenge necessary monitoring and reporting by site, type and action will be undertaken, and any supporting information will be retained.(5) Audits will be commissioned and observed by Robe's HSE department and be performed by a third party on a regular basis. (6) Calculation of Greenhouse Gas Emissions. (7) All staff and contractors will attend a HSE Induction that includes an Energy Efficiency and Greenhouse Challenge section. (8) Progressive rehabilitation will be undertaken where possible (refer to West Angelas Mine Site Management Plan and West Angelas Rehabilitation and Decommissioning Plan), and (9) Land clearing will be kept to a minimum (refer to West Angelas Rehabilitation and Decommissioning Plan). | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | | Energy Advisor | Construction | Implementation (Construction) | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Greenhouse Gas Emission Management Plan | Construction Performance Indicators - 4.1.5 | Construction efficiency is reported as total energy (MJ) used and CO2 (kg) emitted and recorded. Note given the low productivity of the West Angelas vegetation, CO2 emissions from vegetation clearing and CO2 sinks due to revegetation will not be included in the emission calculations. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | | Energy Advisor | Construction | Implementation (Construction) | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Greenhouse Gas Emission Management Plan | Operation - Management Actions - Abatement Actions - 5.1.3.1 | Robe will undertake the following management actions: (1) The Robe Greenhouse Challenge Coordinator will coordinate Robe's Greenhouse Challenge response. (2) Energy efficient design or equipment modifications (abatement actions) will be considered for implementation, subject Robe's approval process. (3) To ensure abatement actions are dynamic and not just reviewed annually, progress on existing action and any new action will be recorded in RAMS. (4) As part of the commitment to the Greenhouse Challenge necessary monitoring and reporting by site, type and action will be undertaken, and any supporting information will be retained, (5) Audits will be commissioned and observed by Robe's HSE department and be performed by a third party on a regular basis. (6) Greenhouse Gas Emissions will be calculated. (7) All staff and contractors will attend a HSE Induction that includes an Energy Efficiency and Greenhouse Challenge section. (8) Progressive rehabilitation will be undertaken where possible (refer to West Angelas Mine Site Management Plan and West Angelas Rehabilitation and Decommissioning Plan), and (9) Land clearing will be kept to a minimum (refer to West Angelas Rehabilitation and Decommissioning Plan). | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | | Energy Advisor | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Greenhouse Gas Emission Management Plan | Operation - Performance Indicators - 5.1.4 | The efficiency of operation will be reported as energy (MJ) consumed per tonne of ore processed and CO2 (kg) emitted per tonne of ore processed. Note given the low productivity of the West Angelas vegetation, CO2 emissions from vegetation clearing and CO2 sinks due to revegetation will not be included in the emission calculations. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | | Energy Advisor | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Greenhouse Gas Emission Management Plan | Operation - Performance Indicators - 5.1.4 | Annual disturbance (ha) and rehabilitation (ha) will be reported. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | | Energy Advisor | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | | | |
| West Angelas | West Angelas Operations | Approval | | Greenhouse Gas Emission Management Plan | Operation - Performance Indicators - 5.1.4 | The following data will be used to compile the energy consumption and greenhouse gas emission figures: - Diesel consumption, - Electricity consumption, - Explosive consumption, - Land clearing and rehabilitation data, - LPG consumption, - Natural Gas consumption, - Petrol consumption, - Production statistics as produced from monthly Stockpile Reconciliation, - Solid Wastes, and - Water. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | | Energy Advisor | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | | | |

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| West Angelas | West Angelas Operations | Approval | | Greenhouse Gas Emission Management Plan | Decommissioning - 6 | As the decommissioning concept is yet to be developed, discussion can only be made at a broad level. Rehabilitation will be undertaken progressively. A decommissioning plan will be developed in consultation with all stakeholders (including government and community representatives). | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | | Energy Advisor | Pre-Closure | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |
| West Angelas | West Angelas Operations | Approval | | Groundwater Extraction Management Plan | Decommissioning - Concept - 7.1 | A detailed decommissioning plan will be prepared at least one year prior to the cessation of groundwater abstraction activities. The plan will be prepared in consultation with all stakeholders (including representatives of government agencies, the local pastoralist(s) and community groups). | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Environmental Superintendent | SEA | Pre-Closure | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |
| West Angelas | West Angelas Operations | Approval | | Groundwater Extraction Management Plan | Decommissioning - Concept - 7.1 | The following concept is proposed in the interim for the groundwater extraction facilities : - All abstraction bores will be decommissioned to make them safe to humans and wildlife and free of erosion, - All equipment will be removed and all bores capped at or below ground level, - All access tracks (and other disturbed areas) not required by Robe for monitoring purposes or stakeholders will be progressively rehabilitated (refer Mine Site Rehabilitation and Decommissioning Plan), and - All mined pits will be backfilled with clean fill to above natural groundwater to minimise the deterioration of groundwater quality (refer Rehabilitation and Decommissioning Plan). | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Environmental Superintendent | SEA | Pre-Closure | Operations | DO NOT USE - For Data Upload Only | Y | Y | | | |
| West Angelas | West Angelas Operations | Approval | | Groundwater Extraction Management Plan | Decommissioning - Progressive Rehabilitation - 7.2 | Rehabilitation of existing exploration tracks no longer required will take place once the operational phase begins or sooner if possible. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Environmental Superintendent | SEA | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |
| West Angelas | West Angelas Operations | Approval | | Marine Management Plan | Legislative Requirements - Robe's ERMP Commitments - 2.4.3 | Robe made the following commitments relevant to this Plan in the West Angelas Project ERMP (ecologia,1998): - Turbidity from construction of the Cape Lambert stockpile extension will be kept below defined criteria (refer Appendix 1). - The proponent will prepare and implement a dredging management plan to ensure impacts on marine flora and fauna are minimised, and - Existing dredge spoil dumps will be utilised for spoil disposal. This Marine Management Plan has been prepared to meet those commitments. Robe will continue to ensure that this Plan, the Stockpile Construction Management Plan and the Dredging Management Plan all comply with all these commitments. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |
| West Angelas | West Angelas Operations | Approval | | Marine Management Plan | Existing Management - Land Based Management Measures - Stockpile Expansion Drainage Design - 6.1.1.1 | The requirements for the design to address the water runoff and discharge from land facilities was specified in the WAP Ministerial Conditions (refer Section 2.4.1).<br>The proposed stockpile expansion drainage system is designed to capture any runoff and/or ocean spray and allow it to infiltrate through the sand foundation of the stockpile. The outermost stockpile row has been designed to be approximately 2 metres below the uppermost part of the seawall. This ensures that any iron ore dust contained in the runoff water is filtered by the sand foundation. The proposed new stockpile rows are also flanked by compacted earth, which are at least 4 metres above the foundation level. Implementation of these measures ensures no water runoff or discharge will effect the surrounding marine environment. The existing Robe procedures for spill prevention and response, which are implemented at Cape Lambert, will be continued during stockpile construction and operation phases. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |
| West Angelas | West Angelas Operations | Approval | | Marine Management Plan | Decommissioning - 9 | Under the Robe State Agreement Act, the Cape Lambert Port facilities will become the property of the State when they are no longer in use. If required a decommissioning plan for Cape Lambert will be developed no later than one year before closure of the facility. The plan will be developed in consultation with relevant stakeholders (Government, Cossack Pearls, community etc). | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | | | |

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| West Angelas | West Angelas Operations | Approval | | Mining Proposal 20934 | Robe River Letter | The fibre optic cable (FOC) will be laid in a rift created by a single tyne attached to a Dozer. Once the FOC is put in place, it will be immediately backfilled and then the disturbed ground will be rolled using the roller which is towed by a Dozer. | Mining Act | Department of Mines & Petroleum (DMP) | Specialist EP | EP Advisor | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | | Mining Proposal 20934 | Land Clearing and Topsoil Management | There will be no disturbance of topsoil due to the nature in which the fibre optic cable (FOC) is to be laid. That is, the topsoil remains in situ and the face of the ripping tyne which installs the FOC is only some 0.1 m wide. | Mining Act | Department of Mines & Petroleum (DMP) | Specialist EP | EP Advisor | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | | Mining Proposal 20934 | Flora, Fauna and Weed Management | In the event that weeds are inadvertently introduced, eradication procedures will be undertaken prior to leaving site and in accordance with Company procedures. | Mining Act | Department of Mines & Petroleum (DMP) | Specialist EP | EP Advisor | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | | Mining Proposal 20934 | Rehabilitation | On the completion of the life of the West Angelas Mine Site, the rehabilitation of the fibre optic cable (FOC) corridor will be done as per Company standard and in accordance with Ministerial Statement 514. The primary goal of the rehabilitation is to re-establish a stable land form and a self sustaining system of native vegetation that is similar in diversity, density and cover to pre-disturbance condition and consistent with the on going land use objectives. It is understood that as the FOC is located at a depth of 1 meter below the ground level, it will most probably be left in situ at the time that the West Angelas Mine is rehabilitated. | Mining Act | Department of Mines & Petroleum (DMP) | Specialist EP | EP Advisor | Pre-Closure | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | | Mining Proposal 33113 | 5.5 Power Station Access Road | A sealed, all-weather permanent access road of approximately 1.5km from the existing main West Angelas mine access road to the West Angelas Power Station will be designed and constructed to accommodate all forecasted construction, operational and maintenance traffic to the power station. | Mining Act | Department of Mines & Petroleum (DMP) | Specialist EP | EP Advisor | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | | Mining Proposal 33113 | 5.6 Temporary Construction Disturbance | Temporary construction disturbance will be required to facilitate the construction of the power station. Temporary disturbance will include laydown areas, storage and parking area, offices, construction access roads and topsoil stockpiles. | Mining Act | Department of Mines & Petroleum (DMP) | Specialist EP | EP Advisor | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | | Mining Proposal 33113 | 5.7.3 Fibre Optic Cable | The trench for the fibre optic cable (FOC) will be backfilled and repaired immediately following the installation of the FOC in a continuous process. This will minimise any potential for fauna entrapment. | Mining Act | Department of Mines & Petroleum (DMP) | Specialist EP | EP Advisor | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | | Mining Proposal 33113 | 5.7.5 Borrow | All borrow pits will be located, developed, operated and rehabilitated in accordance with the CEMP and the EMS Borrow Pit Specification and Management Procedure. A programme of work for geotechnical investigations for borrow was approved in May 2011 (REG ID 29988). | Mining Act | Department of Mines & Petroleum (DMP) | Specialist EP | EP Advisor | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | | Mining Proposal 33113 | 7 Environmental Management | Company and its contractors must comply within on any project and includes procedures on the following relevant areas: 1. Ground disturbance and land use management. 2. Soil management. 3. Flora and fauna management. 4. Weed management. 5. Heritage management. 6. Borrow pit management. 7. Air quality and dust management. 8. Water management and drainage. 9. Hydrocarbon management. 10. Noise and vibration management. 11. Greenhouse gas emissions management. 12. Demobilisation, rehabilitation and handover. 13. Waste management. Key aspects are summarised in MP 33113. | Mining Act | Department of Mines & Petroleum (DMP) | Specialist EP | EP Advisor | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |

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| West Angelas | West Angelas Operations | Approval | | Mining Proposal 33113 | 7.2 Flora and Vegetation Management | The Project will aim to minimise loss of native flora and vegetation communities including the actions as set out in Section 12.5 of the CEMP, which includes the requirement that progressive rehabilitation of any disturbed areas which are no longer required will be undertaken where practicable. | Mining Act | Department of Mines & Petroleum (DMP) | Specialist EP | EP Advisor | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | | Mining Proposal 33113 | 7.3 Fauna Management | The Project will comply with the RTIO Wildlife Interaction Guide and Section 12.7 of the CEMP including the following management actions: - All voids i.e. test pits will be visually inspected prior to backfill; - All voids and trenches will be backfilled as soon as practicable once they are no longer required - Vehicle or equipment collisions with fauna will be reported to the Site Supervisor. | Mining Act | Department of Mines & Petroleum (DMP) | Specialist EP | EP Advisor | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | | Mining Proposal 33113 | 7.5 Topsoil Management | Topsoil management will be carried out in accordance with EMS procedure, Soil Resource Management Procedure including the following actions: - Topsoil must be stripped to a depth of 200mm, or if less than 200mm is available due to geology, topography and/or safety then as much as possible; - Prior to collection of topsoil, any surface vegetation will be collected and stockpiled proximate to topsoil stockpiles; - Topsoil stockpiles are to be no more than 2 metres in height; - Topsoil stockpiles are to be located; - The location of stockpiles will be signposted as per the HSEQ MS Site Signage Templates; and - A current register of topsoil stockpiles will be maintained. Project specific topsoil management procedures are addressed in Section 12.4 of the CEMP. | Mining Act | Department of Mines & Petroleum (DMP) | Specialist EP | EP Advisor | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | | Mining Proposal 33113 | 7.11 Borrow and Spill Management | Borrow and spoil associated with construction activities will be managed in accordance with a Geotechnical, Borrow Pit and Spoil Management procedure in Section 12.3 of the CEMP. Key environmental management actions for waste management include: - Drainage and erosion control structures will be developed around the areas to control the impact of substantial rainfall events. - All topsoil shall be removed from the borrow areas and stockpiled along the edge of the borrow area or at dedicated topsoil storage areas for subsequent use in rehabilitation. - Each borrow area will be rehabilitated to a free draining landform. - The removal of borrow material will be limited to inside the RTIO approval permit boundary and RTIO clearing permit boundary area. - Material considered to be at risk of Acid Sulphate Soils will be managed in accordance with the Acid Sulphate Management Plan where required. | Mining Act | Department of Mines & Petroleum (DMP) | Specialist EP | EP Advisor | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | | Mining Proposal 33113 | 8i) Rehabilitation and Closure | General principles for decommissioning of infrastructure include: - Subject to stakeholder negotiation, above ground installations are removed and materials recycled or reused where practicable; - Infrastructure that is located more than 1 metre below the final surface level (e.g. footings, cables) remain in-situ following closure provided they are non-polluting; - Any infrastructure with the potential to be a source of contamination after closure is managed to prevent contamination from occurring. | Mining Act | Department of Mines & Petroleum (DMP) | Closure Specialist | | Pre-Closure | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | | Mining Proposal 33113 | 8 ii) Rehabilitation and Closure | General principles for rehabilitation include: - Where applicable and appropriate, contaminated soils are removed and treated in a landfarm facility; - Rehabilitation is undertaken so as to make the land compatible with the agreed final land use; - Consideration is give to the surface water drainage impacts, and steps taken to ensure appropriate flows following closure; - Compacted soils are ripped in order to improve rehabilitation outcomes; - Rehabilitation is conducted with seeds collected from a provenance zone appropriate for each species; - Completion criteria are agreed with stakeholders as closure approaches; and - Post closure monitoring programmes are developed and implemented to demonstrate progress towards, and compliance with completion criteria. | Mining Act | Department of Mines & Petroleum (DMP) | Rehabilitation Specialist | | Pre-Closure | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | | Mining Proposal 33113 | 8 iii) Rehabilitation and Closure | Rehabilitation of disturbed areas that not required for ongoing operation of the Project will be conducted progressively or after the completion of construction activities in accordance with the HSEQ MS Rehabilitation Handbook. This will include the borrow pits, temporary construction disturbance and any other disturbed areas that are no longer required. The natural landform and drainage patterns will be re-established, stockpiled topsoil and vegetation will be returned, and the area ripped or scarified (dependent on degree of compaction) on the contour. | Mining Act | Department of Mines & Petroleum (DMP) | Rehabilitation Specialist | | Pre-Closure | Operations | DO NOT USE - For Data Upload Only | Y | N | | | |

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| West Angelas | West Angelas Operations | Approval | | Mining Proposal 33113 | 8 iv) Rehabilitation and Closure | The final Rehabilitation and Closure Plan for the West Angelas Project will address options for closure of the West Angelas power station, including decommissioning and rehabilitation if no longer required for other projects or land users in the area. If decommissioning is required, all infrastructure including fuel storage tanks, administration buildings, unloading/loading facilities and other associated infrastructure will be removed. Bituminised surfaces will be broken up and removed to an appropriate disposal site. Disturbed areas will be shaped to re-establish the natural landform and drainage patterns, stockpiled topsoil and vegetation will be returned, and then areas will be ripped or scarified (dependent on degree of compaction) on the contour. Rehabilitated areas will be monitored for erosion and vegetative regrowth. | Mining Act | Department of Mines & Petroleum (DMP) | Closure Specialist | | Pre-Closure | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | | Mining Proposal 33113 | 8 v) Rehabilitation and Closure | RTIO maintains financial provisions for closure of its extensive global mining network in accordance with its corporate obligations. Cost estimates are prepared for each operation using standard unit-rate methodologies, and reviewed annually to ensure currency. | Mining Act | Department of Mines & Petroleum (DMP) | Closure Specialist | | Pre-Closure | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | | Ministerial Statement 514 | Decommissioning and Rehabilitation Management Plan Condition 13-1 | At least six (6) months prior to decommissioning, the proponent shall prepare a Decommissioning and Rehabilitation Management Plan to the requirements of the Environmental Protection Authority on advice of the Department of Environmental Protection, the Department of Conservation and Land Management, the Department of Minerals and Energy and the Water and Rivers Commission. The objectives of this plan are: • to render the minesite areas safe and stable; and • to encourage the re-establishment of self-sustaining ecosystems. This Plan shall address: 1. removal or, if appropriate, retention of plant and infrastructure; 2. (final) rehabilitation of all disturbed areas to a standard suitable for agreed new land use/s; 3. groundwater levels in mine pits; and 4. identification and remediation of contaminated areas, including provision of evidence of notification to relevant statutory authorities. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Closure Specialist | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Ministerial Statement 514 | Decommissioning and Rehabilitation Management Plan Condition 13-2 | The proponent shall implement the Decommissioning and Rehabilitation Management Plan required by condition 13-1 until such time as the Minister for the Environment, on advice of the Environmental Protection Authority and the Department of Minerals and Energy, determines that decommissioning and rehabilitation are complete. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Closure Specialist | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Ministerial Statement 514 | Decommissioning and Rehabilitation Management Plan Condition 13-3 | The proponent shall make the Decommissioning and Rehabilitation Management Plan required by condition 13-1 publicly available, to the requirements of the Environmental Protection Authority. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Closure Specialist | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Ministerial Statement 514 | Schedule 2 - Commitment 5 | An Environmental Management Plan will be prepared and implemented and which would include but not be limited to consideration of: - cracking clay communities; - Mulga communities; - flora and fauna with special management needs; - rehabilitation; - drainage design along the railway; - fire and dust management; - implementation of relevant aspects of DME guidelines; -timing for implementation of commitments; - reporting. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Environment Superintendent | SEA | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |

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| West Angelas | West Angelas Operations | Approval | | Ministerial Statement 514 | Schedule 2 - Commitment 5 - Objective | To ensure the environment is protected by consolidated environmental management requirements into one concise document. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Environment Superintendent | SEA | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Ministerial Statement 514 | Schedule 2 - Commitment 5 - Action | Plan to be prepared prior to construction on advice of DEP, where proponent to continue to update existing environmental management systems which would include, but not be limited to consideration of: - prevention of impacts to cracking clay communities in the minesite area by isolation from disturbance (e.g. using environmental exclusion zones) and preventing the incision of environmental weeds; - prevention of impacts to significant association of Mulga over Chenopodiaceous shrubs and hummock grasses (6adh25, site 892A), particularly by avoiding changes to surface hydrology; - management of flora and fauna species of conservation value which need special management; - rehabilitation and revegetation of disturbed areas with particular attention to incorporating species of conservation and scientific significance and locally collected seed; - drainage design along the railway at watercourse crossings and through sheet flow areas (i.e. mulga); - weed management including the minesite and railways; - fire management; - dust management, implementation of Department of Minerals and Energy guidelines for Mining in Arid Environments. Asbestos Management in Mining, and Environmental Management of Quarries; - measures to prevent contamination of groundwater and surface waters; - an overview of timing for implementation of commitments; and - reporting requirements, including those for the Greenhouse Challenge Programme. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Environment Superintendent | SEA | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Ministerial Statement 514 | Schedule 2 - Commitment 5 - Measurement / Compliance Criteria | Annual Performance and Compliance Report. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Environment Superintendent | SEA | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | 15/06/2032 | Miscellaneous Licence 47/409 | 6 | All topsoil that may be removed ahead of pipe laying operations to be stockpiled for replacement in accordance with the directions of the Environmental Officer, Department of Mines and Petroleum. | Mining Act | Department of Mines & Petroleum (DMP) | Registered Manager | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | 15/06/2032 | Miscellaneous Licence 47/409 | 27 | The area of the licence to be reduced as soon as practicable after construction, to a minimum for the safe maintenance and operation of the railway line and associated infrastructure. | Mining Act | Department of Mines & Petroleum (DMP) | Registered Manager | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | 15/06/2032 | Miscellaneous Licence 47/409 | 28 | On completion of the life of mining operations in relation to this licence the holder shall: - remove all installations constructed pursuant to this licence -cover all wells and holes in the ground to such a degree of safety as shall be determined by the Environmental Officer, Department of Mines and Petroleum -on such areas cleared of natural growth by the holder or any of it agents, the holder shall plant trees and/or shrubs and/or any other plant as shall conform to the general pattern and type of growth in the area and as directed by the Environmental Officer, Department of Mines and Petroleum and properly maintain same until the Environmental Officer advises growth is self supporting; unless the Mining Registrar or Minister responsible for the Mining Act 1978 orders or consents otherwise. | Mining Act | Department of Mines & Petroleum (DMP) | Registered Manager | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |

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| West Angelas | West Angelas Operations | Approval | 15/06/2032 | Miscellaneous Licence 47/409 | 31 | All topsoil and vegetation being removed ahead of all mining operations and being stockpiled appropriately for later respreading or immediately respread as rehabilitation progresses. | Mining Act | Department of Mines & Petroleum (DMP) | Registered Manager | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | 16/04/2013 | Miscellaneous Licence 47/41 | 10 | On completion of the life of mining operations in relation to Miscellaneous Licence 47/41 the holder shall: -remove all installations constructed pursuant to this licence -cover all wells and holes in the ground to such a degree of safety as shall be determined by the Inspector -on such areas cleared of natural growth by the holder or any of it agents, the holder shall plant trees and/or shrubs and/or any other plant as shall conform to the general pattern and type of growth in the area and as directed by the Inspector and properly maintain same until the Inspector advises growth is self supporting; unless the Mining Registrar or Minister for Mines orders or consents otherwise. | Mining Act | Department of Mines & Petroleum (DMP) | Registered Manager | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | 04/09/2021 | Miscellaneous Licence 47/52 | 3 | All surface holes drilled for the purpose of exploration are to be capped, filled or otherwise made safe immediately after completion. | Mining Act | Department of Mines & Petroleum (DMP) | Registered Manager | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | 04/09/2021 | Miscellaneous Licence 47/52 | 4 | All disturbances to the surface of the land made as a result of exploration, including costeans, drill pads, grid lines and access tracks, being backfilled and rehabilitated to the satisfaction of the Environmental Officer, Department of Mines and Petroleum (DMP). Backfilling and rehabilitation being required no later than 6 months after excavation unless otherwise approved in writing by the Environmental Officer, DMP. | Mining Act | Department of Mines & Petroleum (DMP) | Registered Manager | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | 04/09/2021 | Miscellaneous Licence 47/52 | 5 | All waste materials, rubbish, plastic sample bags, abandoned equipment and temporary buildings being removed from the mining tenement prior to or at the termination of the exploration program. | Mining Act | Department of Mines & Petroleum (DMP) | Registered Manager | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | 04/09/2021 | Miscellaneous Licence 47/52 | 6 | Unless the written approval of the Environmental Officer, DMP is first obtained, the use of drilling rigs, scrapers, bulldozers, backhoes or other mechanised equipment for surface disturbance or the excavation or costeans is prohibited. Following approval, all topsoil being removed ahead of mining operations and separately stockpiled for replacement after backfilling and/or completion of operations. | Mining Act | Department of Mines & Petroleum (DMP) | Registered Manager | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | 04/09/2021 | Miscellaneous Licence 47/52 | 9 | All topsoil and vegetation being removed ahead of all mining operations and being stockpiled appropriately for later respreading or immediately respread as rehabilitation progresses. | Mining Act | Department of Mines & Petroleum (DMP) | Registered Manager | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | 04/09/2021 | Miscellaneous Licence 47/53 | 4 | All topsoil and vegetation being removed ahead of all mining operations and being stockpiled appropriately for later respreading or immediately respread as rehabilitation progresses. | Mining Act | Department of Mines & Petroleum (DMP) | Registered Manager | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | | | |
| West Angelas | West Angelas Operations | Approval | 04/09/2021 | Miscellaneous Licence 47/53 | 5 | At the completion of operations, all buildings and structures being removed from site or demolished and buried to the satisfaction of the Director, Environment Division, DMP. | Mining Act | Department of Mines & Petroleum (DMP) | Registered Manager | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | | | |
| West Angelas | West Angelas Operations | Approval | 04/09/2021 | Miscellaneous Licence 47/53 | 6 | All rubbish and scrap is to be progressively disposed of in a suitable manner. | Mining Act | Department of Mines & Petroleum (DMP) | Registered Manager | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | | | |

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| West Angelas | West Angelas Operations | Approval | 04/09/2021 | Miscellaneous Licence 47/54 | 2 | All topsoil that may be removed ahead of pipe laying operations to be stockpiled for replacement in accordance with the directions of the Environmental Officer, Department of Mines and Petroleum. | Mining Act | Department of Mines & Petroleum (DMP) | Registered Manager | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | 04/09/2021 | Miscellaneous Licence 47/54 | 9 | On completion of the life of mining operations in relation to this licence the holder shall: - remove all installations constructed pursuant to this licence -on such areas cleared of natural growth by the holder or any of it agents, the holder shall plant trees and/or shrubs and/or any other plant as shall conform to the general pattern and type of growth in the area and as directed by the Inspector and properly maintain same until the Inspector advises regrowth is self supporting; unless the Minister for Mines orders or consents otherwise. | Mining Act | Department of Mines & Petroleum (DMP) | Registered Manager | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | 15/04/2020 | Miscellaneous Licence 52/75 | 2 | All topsoil that may be removed ahead of pipe laying operations to be stockpiled for replacement in accordance with the directions of the Inspector. | Mining Act | Department of Mines & Petroleum (DMP) | Registered Manager | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | 15/04/2020 | Miscellaneous Licence 52/75 | 9 | On completion of the life of mining operations in relation to this licence the holder shall: - remove all installations constructed pursuant to this licence -on such areas cleared of natural growth by the holder or any of it agents, the holder shall plant trees and/or shrubs and/or any other plant as shall conform to the general pattern and type of growth in the area and as directed by the Inspector and properly maintain same until the Inspector advises regrowth is self supporting; unless the Minister for Mines orders or consents otherwise. | Mining Act | Department of Mines & Petroleum (DMP) | Registered Manager | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | 15/04/2020 | Miscellaneous Licence 52/75 | 19 | All topsoil and vegetation being removed ahead of all mining operations and being stockpiled appropriately for later respreading or immediately respread as rehabilitation progresses. | Mining Act | Department of Mines & Petroleum (DMP) | Registered Manager | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | | Operations Weed Management Plan | Pre-Construction Management Actions - Hygiene Procedure - 4.4.3 | Development of hygiene procedures which will apply to exploration and to all phases of project development and operation. The hygiene procedures will encompass and include: (8) All earthmoving and mobile construction equipment will be washed down and cleaned of all vegetative, soil and rock material, and an inspection certificate provided, before mobilisations to any of the three weed management priority areas (Weed management priority areas as for Section 4.4.1), to minimise the risk of introducing and spreading weeds. (9) A wash down area will be established at the West Angelas Minesite, with all drainage being directed to into a substantial sump (1 metre deep ) to trap and contain any seed washed of vehicles and equipment. This sump and wash down area will be surrounded by a 1 metre high windrow to further contain any wash down seed.<br>At locations distant from the West Angelas Minesite mobile washdown facilities will be provided for use in areas of known weed infestation. All vehicles used in infested areas will be cleaned prior to movement to non-infested areas. (10) Any equipment or vehicle considered to have been working in a weed risk area will be cleaned down at this wash down before being remobilised to other areas of the project. (11) Weed Risk areas will be imposed encompassing known infestations to limit vehicular access thereby reducing the potential for dispersal of seed and contaminated soil during the flowering season. During the growth and flowering season after good rains risk of seed dispersal is highest. At other times dispersal of Ruby Dock may only occur through transportation of root stocks. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Environmental Superintendent | SEA | Pre-Construction | Study & Design | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Operations Weed Management Plan | Operation - Monitoring - Systematic Monitoring - 6.6.1 | Refer to Section 4.6.1 | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Environmental Superintendent | SEA | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | | | |

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| West Angelas | West Angelas Operations | Approval | | Operations Weed Management Plan | Operation - Monitoring - Adhoc Infestation Reporting - 6.6.2 | Refer to Section 4.6.2 | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Environmental Superintendent | SEA | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C<br>One off | 01/01/1900 | 6 Year<br>Annual<br>Other |
| West Angelas | West Angelas Operations | Approval | | Operations Weed Management Plan | Decommissioning - 7 | Any rehabilitation or decommissioning activity of weed infested areas will be undertaken in a manner which is consistent with the Minesite Decommissioning and Rehabilitation Plan. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Environmental Superintendent | SEA | Pre-Closure | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C<br>One off | 01/01/1900 | 6 Year<br>Annual<br>Other |
| West Angelas | West Angelas Operations | Approval | 30/06/2012 | Programme of Work approval for exploration on G47/1235 and G47/1236 Registration ID: 29988 | Cover letter | To securely plug and backfill to surface all drill holes and remove all sample bags within 6 months of drilling. | Mining Act | Department of Mines & Petroleum (DMP) | Specialist EP | EP Advisor | Construction | Implementation (Construction) | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | 30/06/2012 | Programme of Work approval for exploration on G47/1235 and G47/1236 Registration ID: 29988 | Environmental Management and Methods of Minimising Disturbance | Vegetation stockpiled separately for use in rehabilitation when constructing drill pads. - Topsoil and vegetation stockpiled separately for use in rehabilitation when constructing sumps and/or costeans. | Mining Act | Department of Mines & Petroleum (DMP) | Specialist EP | EP Advisor | Construction | Implementation (Construction) | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | 30/06/2012 | Programme of Work approval for exploration on G47/1235 and G47/1236 Registration ID: 29988 | Rehabilitation Practices and Timing | Drill holes plugged immediately. -Drill holes securely plugged below ground at minimum depth of 400mm within 6 months of drilling (if not using concrete, conical plugs). -Excavations (e.g. sumps, costeans etc.) backfilled and respread with topsoil and cleared vegetation.-Ripping of compacted areas on the contour. - Blocking access to tracks. - Drill sample piles rehabilitated or buried. -Sample bags removed within 6 months of drilling. - All rubbish removed from site (including any hydrocarbon spills). | Mining Act | Department of Mines & Petroleum (DMP) | Specialist EP | EP Advisor | Construction | Implementation (Construction) | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | 15/05/2013 | Programme of Work approval for exploration on L 47/409 and L 52/75. Registration ID: 34687 | Cover letter | To securely plug and backfill to surface all drill holes and remove all sample bags within 6 months of drilling. | Mining Act | Department of Mines & Petroleum (DMP) | Specialist EP | EP Advisor | Construction | Implementation (Construction) | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | 15/05/2013 | Programme of Work approval for exploration on L 47/409 and L 52/75. Registration ID: 34687 | Environmental Management and Methods of Minimising Disturbance | Vegetation stockpiled separately for use in rehabilitation when constructing drill pads. - Topsoil and vegetation stockpiled separately for use in rehabilitation when constructing sumps and/or costeans. | Mining Act | Department of Mines & Petroleum (DMP) | Specialist EP | EP Advisor | Construction | Implementation (Construction) | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |

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| West Angelas | West Angelas Operations | Approval | 15/05/2013 | Programme of Work approval for exploration on L 47/409 and L 52/75. Registration ID: 34687 | Rehabilitation Practices and Timing | Drill holes plugged immediately. -Drill holes securely plugged below ground at minimum depth of 400mm within 6 months of drilling (if not using concrete, conical plugs). - Excavations (e.g. sumps, costeans etc.) backfilled and respread with topsoil and cleared vegetation. - Ripping of compacted areas on the contour. - Blocking access to tracks. - Drill sample piles rehabilitated or buried. • Sample bags removed within 6 months of drilling. • All rubbish removed from site (including any hydrocarbon spills). | Mining Act | Department of Mines & Petroleum (DMP) | Specialist EP | EP Advisor | Construction | Implementation (Construction) | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | 30/05/2012 | Programme of Work approval for exploration on L 47/52 Registration ID: 34829 | Cover Letter | To securely plug and backfill to surface all drill holes and remove all sample bags within 6 months of drilling. | Mining Act | Department of Mines & Petroleum (DMP) | Specialist EP | EP Advisor | Construction | Implementation (Construction) | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | 30/05/2012 | Programme of Work approval for exploration on L 47/52 Registration ID: 34829 | Recommended further conditions for Miscellaneous Licence 47/52 Condition 9 | All topsoil and vegetation being removed ahead of all mining operations and being stockpiled appropriately for later respreading or immediately respread as rehabilitation progresses. | Mining Act | Department of Mines & Petroleum (DMP) | Specialist EP | EP Advisor | Construction | Implementation (Construction) | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | 30/05/2012 | Programme of Work approval for exploration on L 47/52 Registration ID: 34829 | Environmental Management and Methods | Vegetation stockpiled separately for use in rehabilitation when constructing drill pads. -Topsoil and vegetation stockpiled separately for use in rehabilitation when constructing sumps and/or costeans. | Mining Act | Department of Mines & Petroleum (DMP) | Specialist EP | EP Advisor | Construction | Implementation (Construction) | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | 30/05/2012 | Programme of Work approval for exploration on L 47/52 Registration ID: 34829 | Rehabilitation Practices and Timing | Excavations (e.g. sumps, costeans etc.) backfilled and respread with topsoil and cleared vegetation. -Ripping of compacted areas on the contour. -Blocking access to tracks. -All rubbish removed from site (including any hydrocarbon spills). | Mining Act | Department of Mines & Petroleum (DMP) | Specialist EP | EP Advisor | Construction | Implementation (Construction) | DO NOT USE - For Data Upload Only | Y | N | One off | 01/01/1900 | One off |
| West Angelas | West Angelas Operations | Approval | | Rail Route Environmental Management Plan | Objectives - 1.3 | The Rail Route Management Plan has the following overall objectives: - Design and construct the railway to minimise the area of disturbance and associated impacts of vegetation clearance on flora, fauna and soil stability, - In particular, minimise the impact of vegetation clearance on declared rare & priority flora and vegetation communities of significant conservation value, - Design, construct and operate the railway to minimise the impact on natural surface drainage systems, - Design, construct and operate the railway to prevent or minimise the impact on the quality of surface water and groundwater, - Design and construct the railway to minimise disturbance to landforms, - Construct and operate the railway to minimise the risk of fire and protect personnel and Company assets, - Construct and operate the railway to minimise dust generation, - Design, construct and operate the railway to minimise greenhouse gas emissions, - Design and construct the railway to minimise potential visual impacts, and - Design and construct to avoid disturbance to Aboriginal ethnographic and archaeological sites unless approval has been given under Section 18 of the Aboriginal Heritage Act (1972). | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Utilities | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |

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| West Angelas | West Angelas Operations | Approval | | Rail Route Environmental Management Plan | Pre-Construction Existing Environment Landform - 4.2.8 | Construction of the railway will result in changes to the existing landforms. These changes will manifest themselves in the form of cut and fill. The total bulk fill required is 6.5 million cubic metres of which 3.3 million cubic metres comes from cuttings. Particular gradients are necessary for heavy haul railways. These gradient requirements in very flat country can be achieved through minimal use of cuts, but in undulating terrain, cuts cannot be avoided. Steeper grades that reduce the depths of cuts are possible but with a resultant increase in greenhouse gas emissions over the life of the railway. The West Angelas Project has attempted to balance requirements for cut and fill throughout the length of the railway, depending on the nature of the terrain. Also to minimise drainage impacts, the rail formation has been designed to be high enough so that drainage structures of a sufficient size can be placed over the natural ground level. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Utilities | | Pre-Construction | Study & Design | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |
| West Angelas | West Angelas Operations | Approval | | Rail Route Environmental Management Plan | Construction Management Actions - Vegetation Communities - 5.4.1 | Progressive rehabilitation of disturbed areas will be undertaken with topsoil as per the guidelines in Appendix 9 and Robes Mine Rehabilitation Training Course, Operators Manual 1997. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Utilities | | Construction | Implementation (Construction) | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |
| West Angelas | West Angelas Operations | Approval | | Rail Route Environmental Management Plan | Construction Management Actions - Fauna - 5.4.4 | Vegetation that is cleared will either be stockpiled for later use or used directly on disturbed areas to be rehabilitated. This vegetation will provide habitat shelter and food for fauna. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Utilities | | Construction | Implementation (Construction) | DO NOT USE - For Data Upload Only | Y | Y | | | |
| West Angelas | West Angelas Operations | Approval | | Rail Route Environmental Management Plan | Construction Management Actions - Fauna - 5.4.4 | Progressive rehabilitation of disturbed areas will be undertaken to restore fauna habitats. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Utilities | | Construction | Implementation (Construction) | DO NOT USE - For Data Upload Only | Y | Y | | | |
| West Angelas | West Angelas Operations | Approval | | Rail Route Environmental Management Plan | Construction Management Actions - Surface Water Hydrology - Erosion control of other disturbed areas - 5.4.5 | Rehabilitation of disturbed areas will aim to re-establish natural drainage patterns. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Utilities | | Construction | Implementation (Construction) | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |
| West Angelas | West Angelas Operations | Approval | | Rail Route Environmental Management Plan | Construction Management Actions - Visual Amenity - 5.4.18 | To reduce visual impacts the following measures will be undertaken when constructing the rail line and its associated infrastructure and earthworks: - Progressive rehabilitation of the Project area to limit length of visual impact. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Utilities | | Construction | Implementation (Construction) | DO NOT USE - For Data Upload Only | Y | Y | | | |
| West Angelas | West Angelas Operations | Approval | | Rail Route Environmental Management Plan | Operation - Potential Impacts - Quarry - 6.3.4 | After construction is complete the quarry will not be decommissioned but left in a safe condition so that rail ballast may still be obtained for possible future maintenance activities. - If surface drainage and erosion control structures around the quarry site are not maintained then erosion can occur, causing the loss of soils and reducing the potential for rehabilitation success. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Utilities | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P | 01/01/1900 | 6 Year |

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| West Angelas | West Angelas Operations | Approval | | Rail Route Environmental Management Plan | Decommissioning - Objectives - 7.1 | To ensure that rehabilitation of areas renders them safe and stable and encourages the re-establishment of self-sustaining vegetation. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Utilities | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Rail Route Environmental Management Plan | Decommissioning - Concept - 7.2 | Decommissioning and rehabilitation of the infrastructure required for the constructional phase will follow the progressive rehabilitation and monitoring requirements documented within the Decommissioning and Rehabilitation Plan. In particular: - Groundwater bores will not be totally decommissioned but capped and locked for potential future use. - Drill pads and access tracks will be rehabilitated. - Borrow pits will be progressively rehabilitated after they have finished being used. - After construction is complete, the quarry will be maintained in case there is a need for rail ballast for future maintenance activities. It will be decommissioned and rehabilitated at the end of the operational life of the Mine. - Access roads and tracks to borrow pits, camps and work sites will be rehabilitated. The rail line access road, quarry access road and roads to radio communication towers will be maintained during the operational life of the Mine. - Camps and their associated infrastructure will be decommissioned and rehabilitated after they have finished being used. Six months prior to the decommissioning of the West Angelas Project, discussion will be held with the Department of Resources Development on the future use and strategic value of the railway line prior to the completion of a detailed decommissioning strategy. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Utilities | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Rail Route Environmental Management Plan | Appendix 4: Vegetation Clearance Procedures | Appendix 4 details the vegetation clearing procedures to apply pursuant to section 4 and 5 of this plan, including the following rehabilitation requirements: - Any cleared vegetation should be stockpiled for re-spreading either directly or at a later date to minimise erosion and aid in rehabilitation. - After vegetation has been cleared the top 100mm profile of soil should be removed and stockpiled separately from the vegetation. - Do not store top soil in large heaps. Once soils are disturbed, biological and composting processes are activated which slowly destroy both the seed bank and biological content. Low mounds of no more than 1.5 metres high are recommended. - Plan to use stockpiles of top soil as soon as possible. Where it is known that the material will be stockpiled for long periods, i.e.. a number of years, the surface profile can be roughly spread and ripped to contour, promoting germination. This will encourage plant establishment and the setting of seed to enrich the seed bank. - Store top soil and cleared vegetation where it will not be affected during construction activities, and away from areas of surface water flow. - Soils should not be stripped when they are wet as this can lead to compaction and loss of soil structure. - The risk of topsoil stockpiles becoming a source of airborne dust should be minimised though an initial application of water where practicable. This should reduce dust during the establishment of the stockpile, as well as encouraging the growth of vegetation and the formation of a crust which retards dust generation. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Utilities | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |
| West Angelas | West Angelas Operations | Approval | | Rail Route Environmental Management Plan | Appendix 6: Hydrocarbons & Chemical Spill Response Procedures For Minor Spills | Appendix 6 details the procedures to apply when managing minor spills of hydrocarbons and chemicals, pursuant to section 5 of this plan, including the following closure and reporting requirements: - Excavate and remove any soils contaminated with hydrocarbons to an allocated bioremediation site in accordance with EPA Guidelines for Oil Farming of Oily Wastes. Disposal of oily wastes from this site will comply with the requirements of the DEP Division of Waste Management. - All spills should be reported to Supervisor and incident reports completed. - In light of any actions taken, record any necessary changes to procedures. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Utilities | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year<br>Annual |

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| West Angelas | West Angelas Operations | Approval | | Rail Route Environmental Management Plan | Appendix 7: Vehicle Access Track Procedures | Appendix 6 details the procedures to apply when managing minor spills of hydrocarbons and chemicals, pursuant to sections 4 and 5 of this plan, including the following closure requirements: - Where provision of a new track is unavoidable, it will be constructed in a manner best designed to : - minimise long term visual impact; - minimise land clearance and hence disturbance to soil, vegetation and fauna habitats i.e.. the more direct the track the less clearing required avoid unnecessary interference or blockage to natural drainage lines; support the intended use of and traffic volume; tracks flanking the base of the hills generally avoid the more heavily wooded creek bed areas. - Clearing should only be carried out if access cannot be obtained via existing tracks, fence lines, firebreaks or off road driving, and only after relevant authorities and landholders have been notified and approval received where necessary. - Clearing of tracks and grid lines for vehicle access is to be carried out with a bulldozer equipped with a scrub rake. The rake is kept above ground level during clearing so as to preserve root stock material and reduce soil surface damage. - Avoid creating windrows which may leave permanent scars on the land and have the potential to block or channel water flow along tracks and cause severe erosion problems. - Any water course crossed by a track should be excavated to the base of the watercourse, not filled in, to prevent erosion of the road during high rainfall events. - Incidental areas disturbed during track construction should be rehabilitated promptly following construction. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Utilities | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |
| West Angelas | West Angelas Operations | Approval | | Rail Route Environmental Management Plan | Appendix 8: Drill Pad Procedures | Appendix 6 details the procedures to apply when managing minor spills of hydrocarbons and chemicals, pursuant to sections 5 of this plan, including the following closure requirements: - Earthworks where needed should be done by a bulldozer equipped with a scrub blade (rake) to remove vegetation and place in a stockpile to the side, preferably on the uphill side of the drill pad. - If the drill pad is located on steep and rugged terrain, a bulldozer equipped with a blade will be required. Top soil should be stored on the uphill side of the pad. - All top soil disturbed during the construction of a drill pad should be pushed to one side and stockpiled for future rehabilitation. - All drill holes are to be plugged with a cement drill hole plug immediately after drilling of the hole is complete. No holes are to be left uncovered. - Any oil spillage (eg. hydraulic oil, grease) should be collected and removed from drill pad sites. This will involve the collecting of oil/grease into bags or buckets. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Utilities | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |
| West Angelas | West Angelas Operations | Approval | | Rail Route Environmental Management Plan | Appendix 9: Guidelines for Borrow Pit Development and Rehabilitation for The Pilbara Region | Appendix 9 details the borrow pit guidelines that apply pursuant to section 5 of this plan, including the expected environmental impacts of borrow pits and detailed rehabilitation and closure requirements | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Utilities | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |
| West Angelas | West Angelas Operations | Approval | | Rail Route Environmental Management Plan | Management Programme Summary - 10 | A table summarising the objectives, actions, timing and performance indicators is set out in this section. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Utilities | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P MSR C | 01/01/1900 | 6 Year Annual |

## LAORS Approval / Agreement and

**Type: Approval / Agreement, Site Name: West Angelas, Project Name: All, Discipline: All, Approval Type: All, Regulatory Body: All, Status: All, Closure Obligation: Yes, Enviroment Reporting Requirement: No, Included Historic: No, Phase Regulatory: All, Phase RTIO: All, Document Details: No**

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| West Angelas | West Angelas Operations | Approval | | Rail Route Environmental Management Plan | Appendix 10-Summary of Management Actions Relating to Ministerial Conditions | Appendix 10 sets out a summary of the management actions and how these relate to the conditions of the Ministerial statement. | EP Act Part IV (Ministerial) | Environmental Protection Authority (EPA) | Utilities | | Productive Mining | Operations | DO NOT USE - For Data Upload Only | Y | Y | MSR P<br>MSR C | 01/01/1900 | 6 Year Annual |

# Appendix B – Closure knowledge database

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# Rio Tinto West Angelas closure knowledge database

The closure knowledge database is a summary of the technical reports that directly or indirectly contribute to the development of the closure plan. These documents do not form part of the report and are for indicative purposes only.

The knowledge and understanding of closure issues and management strategies evolve and improved over time, coincident with the development of the mining operation. As a result, some components of some reports and studies may be superseded by new research or studies. While the closure plan addresses the current state of understanding and strategy for closure, the closure knowledge database captures the historical development of closure knowledge, and demonstrates how experience and knowledge developed at other Rio Tinto sites has been considered during the development of the closure plan and across the life of the operation. Accordingly, some information presented in the closure knowledge database may be obsolete.

Technical reports supporting the closure of the operation will be presented as part of the last plan produced prior to the implementation of closure (the Decommissioning Plan).

CONFIDENTIAL

## Geochemical characterisation

**Acid Generating Potential, Selected Core Samples Mt Newman Member BIF, West Angeles Deposit A Open Pit** — **1988**

*A preliminary assessment of the potential for the generation of acid drainage was undertaken on banded iron formation samples from West Angeles Deposit A open pit.*

Only one of the five samples was determine to have acid generating potential. Three of the samples tested contained reactive carbonates.

Internal reference: RTIO-PDE-0030854

**Review of Waste Rock Geochemistry a.General Overview of Acid Base Accounting** — **2006**

*This report contains a general overview of acid base accounting and a summary of the geochemical test work that has been previously completed for various sites and lithologies.*

There are large discrepancies in the total sulfur concentration measured using XRF and LECO machines. The XRF machine underestimates the sulfur concentration at values greater than 2%. Materials with total sulfur concentrations less than 0.1% can contain low capacity PAF material, however, it is considered only to be low additional acid and metalliferous risk if the boundary for inert material and potentially acid forming material is shifted from 0.02%S to 0.1%S. A paste pH result of less than 7 should be sent to the black shale dump and a paste pH result of greater than 7 can be sent to an inert material waste dump.

Internal reference: RTIO-PDE-0021130

**Geochemical Characterisation of Paraburdoo Lens 2, Tom Price North Deposit Dales Gorge and West Angelas Samples** — **2008**

*A geochemical assessment was undertaken on samples from Paraburdoo, Dales Gorge and West Angelas to determine acid generating potential, oxidation rates and leachable contaminants.*

Seven of eight West Angelas (Deposit A) samples studied were classified as potentially acid forming. In samples of banded iron formation and/or shale lithologies from the three mine sites C, S, As, Au, Bi, Mo, Sb, Se, Sn were enriched. Only Mo and Se were readily leachable.

Internal reference: RTIO-PDE-0034616

**Mineralogical Analysis of Potentially Acid Forming Materials** — **2008**

*Quantitative mineralogy (QEM-Scan) for samples of rock collected from Tom Price, Channar, West Angelas, Brockman, Paraburdoo, East Extension, Western Turner Syncline and Hope Downs 1 North was undertaken. Comparisons were made between two methodologies use to characterise potentially acid forming materials; acid base accounting and mineralogical analysis.*

All samples contained elevated total sulfur concentrations and the lithologies were either shale, banded iron formation or dolomite. Pyrite was the dominant mineral contributing to acidity and the dominant sulfate secondary mineralisation consisted of alunite and jarosite.

Internal reference: RTIO-PDE-0053725

**Determination of ARD potential of Rio Tinto Iron Ore (WA) Waste Rock Samples** — **2008**

*This report investigates the use of mineralogy to predict acid and metalliferous drainage potential. Analysis of numerous rocks was undertaken using QEM-SCAN.*

Areas of waste rock which have underdone oxidation can be identified where sulfur-bearing minerals vary between samples in the form of pyrite, alunite and jarosite. The variability of gangue mineral phases suggest that some areas of composite waste rock pile may provide some neutralising potential while other areas will have no neutralising potential. Variable textural and mineralogical controls on sulfide mineral occurrence result in decreased accessibility of pyrite to oxidising fluids.

Internal reference: RTIO-PDE-0051613

**West Angelas ARD and Geochemical Risk Assessment** **2010**

Internal reference:
RTIO-PDE-0052917

*Risk associated with acid rock drainage in the current, possible and future deposits at the West Angelas project area have been investigated.*

Deposit C and G pose low-nil risk of acid and metalliferous drainage. Deposit A, E and F poses a low risk. Deposit D a moderate to low risk and Deposit B a moderate risk. High risks have been classified for WA6 Area (southern West Angelas project area) WA7 Area (northwest of West Angelas project area), WA8 Area (west of Deposit A), WA9 Area (west of Deposit A) and Angelo River.

**Environmental Status of Selenium (Se) in the Pilbara Region of Western Australia – Potential Risk from Iron Ore Mining** **2011**

Internal reference:
RTIO-PDE-0103857

*This report includes information about Selenium geochemistry, distribution in the environment, occurrence in rocks in the Pilbara and potential risks to the environment.*

The Selenium (Se) content of shales containing significant pyrite should be recorded as part of the overall risk assessment for acid and metalliferous mine drainage. However, it should also be noted Se solubility is far less constrained by pH than in the case of metals and near neutral drainage may contain significant Se concentrations in solution. It would be most useful to study the Selenium budget of the wetlands in the Pilbara as, apart from the chance poisoning of livestock from the consumption of plants that have taken up high concentrations of Selenium, impacts are most likely to be felt in wetlands receiving mine site drainage.

**Contaminant Leaching from Non-Sulfidic Waste Material** **2011**

Internal reference:
RTIO-HSE-0145041

*The available leach extract data and information pertaining to the distribution of metals and metalloids in non sulfur materials at neutral pH was reviewed. Based on this review conceptual models for controls on their leaching and mobility were developed.*

The review found that contaminant leaching from non-sulfidic materials was generally very limited. Usually the pH in leach tests was near-neutral (pH 6 to 8), and dissolved contaminant concentration were at or below detection limits. It is believed that a primary leachable contaminant source is the oxidation of sulfide minerals. Release from oxidising sulfides leads to release of soluble reaction products. Under neutral pH conditions, there is the potential for release of these contaminants when those products dissolve.

**Contaminant Leaching from Low-Sulphur Waste Minerals (Summary)** **2011**

Internal reference:
RTIO-PDE-0090689

*RTIO's Geochemical Database was reviewed and based upon this data, conceptual models for controls on the leaching and mobility of a range of metals and metalloids were developed. This summary also describes potential controls on the amount of dissolved element that may be released. This is a summary of a comprehensive report RTIO-PDE-0100104.*

For most contaminants, dissolved concentrations at circum neutral pH (pH 6 to 8) were very low, typically at or below detection limit. Geochemical modelling indicates that water-rock interactions are controlled by equilibrium, for salt, carbonates and sulphates this equilibrium is often source term limited whilst hydroxyl-sulphates and hydroxides are solubility controlled. Results also indicate that sorption plays an important role in solute concentration; weak (but detectable) sorption occurred for selenium and zinc whilst the strongest sorption was evident for cobalt. The review suggested that storage waste facilities containing low-sulfur materials pose a low level of environmental risk however, there is a small risk of increased in mobility of some contaminants if acidic conditions arise. Acidic conditions can sometimes arise from the interactions between iron and aluminium hydroxyl-sulphates and hydroxides.

**West Angelas Deposit B AMD Risk Ranking July 2012** **2012**

Internal reference:
0

*Memo regarding review and update of the 2008 West Angelas deposit B AMD risk assessment and ranking.*

The risk assessment (Terrusi 2008) indicated that the rocks from Deposit B were enriched in As and Fe and elevated in Sn for most strand-tag groups, with Cr, Mn and Pb elevated in some others. It is unlikely that these elements will mobilise under neutral conditions as demonstrated by Brown (2012). The overall AMD hazard score for West Angelas Deposit B is Moderate. One of the largest contributors to the Moderate risk rating is around surface water management. Currently there is a significant creek line that is located where the proposed Deposit B pit is located. Diversions are recommended to control the surface water from entering the pit or mobilising salts from the pit wall that would reduce the chance of contaminants from polluting the surrounding environment. If the diversion is implemented the AMD risk rating for the deposit would become low.

**Geochemical Assessment of Samples from West Angelas Deposits, B, D and A West** **2013**

Internal reference: RTIO-PDE-0120532

*Report summarising geochemical testing of samples from West Angelas deposits B, D and A west for the purpose of; determining acid forming characteristics of waste rock, provide a preliminary assessment of the likelihood of occurrence of potentially acid forming rock types, assess the reactivity of any sulphide mineralisation to provide estimates of geochemical behaviour and lag times for acidification, identify element enrichments that could be environmentally significant and assess mobilisation of elements, provide recommendation for kinetic testing.*

Testing has been conducted on seven different waste rock types from two deposits of the West Angelas Mine and indicates that 79% of the samples have a low total S content and 71% have a low acid neutralising capacity (ANC). About two thirds of the samples (66%) were NAPP negative and one third (34%) were NAPP positive.Sulphur speciation testing indicated that for all but one of the samples selected, the majority of the sulphur occurs in non-acid generating forms. Results suggested that the total S content of samples from West Angela Mine cannot be used reliably as criteria for identifying PAF material types at the West Angela Mine. Materials represented by the samples may have elevated concentrations of As, Be, Fe, S, Tl and V, however, the solubility of most of these elements at circum-neutral pH was low for the samples that were tested. Overall, 92% of the samples are classified as barren or non-acid forming (NAF) and 8% potentially acid forming (PAF or PAF-LC).

**Greater West Angelas AMD Risk Assessment** **2014**

Internal reference: RTIO-PDE-0120775

*The acid and metalliferous drainage (AMD) risk assessment for the West Angelas deposits has been updated from an assessment completed in June 2008. This current assessment takes into account total sulfur concentrations within rock types, considering recent drillhole data associated with the greater West Angelas area and individually within the currently available final pit shells. Logging data and the samples location with respect to the water table was used to indicate whether sulfur is in the form of sulfide or sulfate minerals. Geochemical data is also assessed to identify enriched elemental concentrations which may pose an environmental risk. This data, along with site specific baseline information, can be used to generate a conceptual site model to describe mechanisms by which acid and metals/metalloids may mobilise and interact with environmental receptors.*

AMD risks for all deposits are low, based on the current pit designs. Although pyrite has been visually identified in drillhole samples, no pyrite samples are located within the current proposed pit shells. The sulfur associated with elevated-sulfur samples are likely to be associated with sulfate minerals including gypsum which will not generate acid, or alunite which has the potential for relatively low levels of acid release from elevated-sulfate samples. The low solubility of alunite means that only a low flux of acid (and contaminant) release. Fe, As and Sn, as well as Co, Cr, Cu, Mn, Ni, Pb and Zn have been identified as being enriched in West Angelas deposits and should be monitored in groundwater.

**Oxidation and solute accumulation in dewatered pit wall rocks** **2014**

Internal reference: RTIO-PDE-0109045

*Dewatering and removing the water table may result in de-saturation of sulphide-bearing lithologies. This study was undertaken to review how oxygen ingress and consequent sulphide oxidation of Mount McRae Shales could impact water quality when the groundwater table rebounds after mining.*

## Physical characterisation

**Field rainfall simulator and overland flow study of waste and topsoil erodibility - Nammuldi and West Angelas Mines - Pilbara Iron** **2006**

Internal reference: RTIO-HSE-0036709

*This study was carried out to assess the erodibility of dominat wastes and topsoils on Nammuldi and West Angelas mine sites, to provide a basis for the design of stable landforms for rehabilitation. To determine the erodiblity of materials, simulated rain and overland flows were applied to experimental plots, and measurements made of runoff and sediment in runoff. Erodibility parameters for the WEPP runoff/erosion model were derived from the data, and the model was run using 100-year climate files.*

Several of the West Angelas materials (two wastes, one topsoil) showed a degree of similarity. For those three materials, it appears that - if linear batter slopes are constructed - the maximum landform height likely to be stable is 20 m. If it is essential that waste dumps be constructed to a greater height, then concave profiles and rock armouring could enable a significant increase in landform height. If such options are likely to be requried, forward planning (including sourcing and stockpiling competent rock) would be advisable. The other material studied at West Angelas (low grade fines from the Roche crushing plant) would only give a 10 m high linear batter slope of acceptable stability, and will clearly need to be covered with more erosion-resistant material if batter slopes higher than 10 m are to be rehabilitated.

## Water interactions and pit lakes

**Geochemical and hydrological processes controlling groundwater salinity of a large inland wetland of northwest Australia** **2013**

Internal reference: RTIO-HSE-0198428

*Understanding mechanisms of hydrochemical evolution of groundwater under saline and brine wetlands in arid and semiarid regions is necessary to assess how groundwater extraction or injection in large-scale basins may affect the natural interface between saline–fresh aquifers in those systems. This paper investigated the evolution of groundwater of the Fortescue Marsh, a large inland wetland of northwest Australia.*

The deep groundwater (>50m depth) of the Fortescue Marsh is highly saline (>100g/L), whilst shallow groundwater (~0–20m depth) and surface water are mainly fresh or brackish. Currently, the marsh is mainly recharged by occasional floodwater. Consequently, salt in the marsh is concentrated by evaporation of rainfall. It was found that groundwater associated with the marsh could be divided into two groups characterised by their stable isotope compositions; i) fresh and brackish groundwater (TDS b10 g L−1; δ18O −8.0 ± 0.9‰) and ii) saline and brine groundwater (TDS N10 g L−1, δ18O varies from +2.5 to −7.2‰). Fresh groundwater was evaporated by<20% compared to rainwater. Brackish water mainly reflects modern recharge whilst saline and brine groundwater reflects mixing between modern rainfall, brackish water and relatively old groundwater.

## Flora

**Flora & Vegetation Survey of Orebody A & B West Angela Hill and Rail Route Options March 1998** **1998**

Internal reference: RTIO-HSE-0202800

*Report defines premining flora and vegetation communities for West Angelas Deposits A and B as well as the access road and proposed rail alignment options.*

There are two vegetation types of conservation signficance in the West Angelas Deposit A and B and access road study areas. These consist of Cracking Clays and Mulga stands. Cracking clays found both to the west of Deposit A and south of Deposit B are locally signficant as the contain species which are both rare and edaphically restricted. There are two signficant stands of Mulga in the West Angelas area. The first of which is west of Deposit A on a broad alluvial fan. This area is of conservation signficance not because of its regional restriction as it is found elsewhere but beceause of the condition of the stand as it has had little to no impact from grazing. There are two vegetation types of conservation significance in the West Angelas deposit A and B and access road study areas. These consist of Cracking Clays and Mulga stands. Cracking clays found both to the west of Deposit A and south of Deposit B are locally significant as the contain species which are both rare and edaphically restricted. There are two significant stands of Mulga in the West Angelas area. The first of which is west of Deposit A on a broad alluvial fan. This area is of conservation significance not because of its regional restriction as it is found elsewhere but because of the condition of the stand as it has had little to no impact from grazing. The Mulga stand north of Deposit B and the mine access road is of high conservation value (vegetation type (6adb231)) and it appears distinct as there is limited about on overlap with associated species as the dominate species is Acacia aneura var. (green, flat; MET 15, 946). This species is only dominate in one other association.

**Robe River Mining Southern Spur rail route Mulga monitoring programme – December 2004** **2004**

Internal reference: 0

*Results of 2004 Mulga monitoring programme for the Southern Spur of the West Angelas Rail.*

The results suggest that there has been no decline in the health of perennial emergent and perennial grasses along the southern spur rail route, with no overall increase in the cover of perennial grasses and health of perennial emergent at the control and experimental sites.

**Vegetation and Flora Survey of Deposit E and F** **2006**

Internal reference: 0

*Biota Environmental Sciences (Biota) was commissioned to undertake a flora and vegetation survey of Robe River Mining's (Robe's) Deposits E/F study area at West Angelas in May 2004. This report describes the results of this study, and also integrates data previously collected from the area.*

Twelve vegetation types were identified within the Deposits E/F study area. The following vegetation types within the study area are considered to have moderate conservation significance: • Mulga vegetation types M1-M5: which was considered to be relatively restricted in the area, and also comprise ecosystems at risk in the form of grove/intergrove and valley floor mulga; • Vegetation types Hi and H3 of stony hills and gorges respectively: these comprised the main mapping units from which the undescribed spinifex species Triodia sp. Mt Ella was recorded. This Priority 3 taxon is known only from the vicinity of West Angelas, and is apparently uncommon and restricted in distribution. It can therefore be surmised that any vegetation type in which this species is a significant component will also be uncommon and restricted. The remainder of the vegetation types are considered to be of low conservation significance, representing units that are likely to be widely distributed and relatively well represented in the Hamersley Range subregion. None of the vegetation types within the Deposits E/F study area are considered to be sufficiently rare or restricted at a subregional level to warrant designating them as being of high conservation significance. No Declared Rare Flora have been recorded within the Deposits E/F study area. Eight Priority flora have been recorded from the Deposits E/F study area. There were also five records of the Priority 2 Acacia effusa from south of the main study area.

**West Angelas Coondewanna Mulga Monitoring 2008-2009** **2009**

Internal reference:
RTIO-HSE-0145907

*Results of 2009-2009 Mulga monitoring programme for the Southern Spur of the West Angelas Rail.*

The majority of perennial grass test site were moderately to heavily burnt in 2006, and the data from these sites clearly demonstrates that fire is still the dominant influence on the extent of perennial grass cover at these sites, although a partial recovery is now evident. The influence of fire on these sites is so great as to mask any other effects which may or may not be present due to change in surface hydrology. Comparison of the mulga health status 2008 data relative to 2002 indicated only six of the 51 transects tested were significantly different, of which three sites declined and three sites improved. As with the perennial grass data, the equal proportion of declining and improving sites suggests that, at least at a broad scale, the rail infrastructure is not resulting in deterioration in mulga health status.

**UWA West Angelas Mulga Report - February2010** **2010**

Internal reference:
0

*Review of long term mulga vegetation monitoring that has been conducted for Rio Tinto ore iron. The review measured any potential impacts of slatered surface hydrology that maybe attributed to rail infrastructure, provide a combined monitroing data set and re-analyse each data set and combine to provide new insight to whether changes in vegetation condition could be attributed to rail infrastructure for the three long term monitoring site of Yandicogina, Marandoo and Coondewanna flats (West Angelas southern rail spur).*

Review, comtination and re-analyse of the three long term data sets found that there were no trends in the combined dataset that indicated that the Central Pilbara Railway has had a negative effect on the density of mulga on either side of the rail line. It was also found that fire is the most significant factor in mulga density and it could not be estiblished if a drainage shadow effect has occured as not soil moisture analyse has been complete upslope or downslope of the rail.

**West Angelas Coondewana Mulga Monitoring 2011** **2012**

Internal reference:
0

*Results of 2011 Mulga monitoring programme for the Southern Spur of the West Angelas Rail.*

No clear trends in changes to total cover of perennial grasses at unburnt or lightly burnt test sites relative to the baseline survey were detected, suggesting that, at least at a broad scale and within this time frame, the rail infrastructure has not resulted in deterioration in the health of these species. Similarly the lack of any clear trend in unburnt or lightly burnt control sites relative to 2001 suggests that seasonal differences between surveys periods have not contributed significantly to the changes in total cover. Data from transects burnt moderately or severely clearly demonstrates that fire remains the major influence on the extent of perennial grass cover. The influence of fire on these transects is likely to mask any other effects which may or may not be present due to change in surface hydrology. There appears to have been a decline in seedling numbers at test sites, and a concurrent increase in shrub numbers, suggesting that some seedlings have grown to the extent that they are now classified as shrubs. The number of trees has increased marginally from the significant decline observed in 2006 post burning, but remains significantly lower that in the baseline survey of 2001. In contrast the cover of perennial grasses at burnt sites is generally now increasing, though still lower then pre-fire levels. Consideration of the location of each transect in the landscape has shown no trend in mulga health status. As with the perennial grass data, an equal proportion of declining and improving sites suggests that, at least at a broad scale, the rail infrastructure is not resulting in deterioration in mulga health status.

**West Angelas Rehabilitation Record**
**South and East Waste Dumps** **2012**

Internal reference:
Rehab close out rep

*Two separate waste dump berms on the West Angelas South waste dump and East waste dump were rehabilitated in 2012.*

The waste material on the berm was highly erodible West Angelas shale material, such that slope angles up to 17 degrees were required. The slopes were dressed with 200mm topsoil, deep ripped and seeded.

**Greater West Angelas Vegetation and Flora Assessment, ecologia, April 2013** **2013**

Internal reference:
RTIO-HSE-0185831

*Rio Tinto (RT) commisioned ecologia Environment (ecologia) to undertake a two phase assessment of the Greater West Angelas Study Area (Deposits C, D, D extension, G, F, H and Mt Ella were surveyed).*

Overall the vegetation condition was found to be excellent. 22 vegetation communities were described. One Priority 1 PEC, West Angelas Cracking-Clays, occurs extensively within the Study Area. This community is further defined as open tussock, on derived cracking-clay loam depressions and flowlines. Local vegetation communities considered to be of conservation significance are detailed including vegetation located in; rocky midslopes, gullies, sandy undulating plains and rocky hilltops.

**West Angelas - Rehabilitation Monitoring Report 2013** **2013**

Internal reference: 0

*This report contains the analysis and summary of results from the 2013 West Angelas rehabilitation monitoring program. This report describes the findings from 2013 monitoring of two transects at the West Angelas east waste dump (WD1 T1 and WD1 T2), and two transects at the south waste dump (WD2 T1 and WD2 T2). For comparison, three reference sites were monitored, viz. C3 and C4 (both located on slopes) and C8 (located on a flatter area).*

As the rehabilitation was monitored when it was only 9 months old, any conclusions regarding whether it has been successful or not will be preliminary, and further monitoring will be required to determine any likely trends over time. Several erosion gullys were recorded in WD1T2, and these may be related to the generally lower cover values recorded compared to WD1 T1. Apart from these, the site appears stable. It is apparent that, despite the two rehabilitated areas being given apparently similar rehabilitation treatments, the developing vegetation in the four transects is quite variable. It can be concluded that rehabilitation at some sites (particularly WD1 T1 and WD2 T2) has begun to develop well, while that at WD2 T1 has not yet developed as well. The vegetation, fauna habitat and erosion data provide a useful baseline for future comparison.

## Fauna

**West Aneglas Vertebrate fauna assessment study April 1998** **1998**

Internal reference: RTIO-HSE-0016008

*Report documenting the findings of a vertebrate fauna assessment survey completed between June and October 1997. This report identifies vertebrate fauna species found, fauna habitats and their conservation significance in the West Angelas mine area.*

Six fauna habitats were identified as being representative of both the landform features and vegetation associations of the mine area; mulga woodland, rocky gullies, cracking clay, creeklines, hilltop and spinifex plain. The ghost Bat Macroderma gigas was recorded in the mine area as well as several other priority and scheduled species were found. Significant habitats have been identified as the Cracking Clay habitat and Mulga woodland.

**West Angelas Stygofauna assessment survey Nov 1998** **1998**

Internal reference: RTIO-HSE-0016004

*The report summarises the findings of the preliminary stygofauna survey for the West Angelas mine and Turee Creek B borefield. The aim of the study was to determine if stygofauna are present in the mine and borefield areas, identify key habitat features and assess potential environmental impacts from water abstraction and detail management options. The study was commissioned to support the Part IV approval for West Angelas.*

Of the 44 bores sampled in the area 6 bores contained stygofauna. Five specimens were collected in mine area and one specimen in the Turee Creek B borefield area. Species have not been identified as little was known at the time of taxonomy of Australian stygofauna. It was determined that most influencing factor for stygofauna habitat is dolerite and to a lesser degree black shale. It is thought that the presence of fractures and weathered zones in these two non-permeable substrates are utilised as habitat in the absence of more suitable habitat. Potential environmental impacts from mine are summarised as arising from mine dewatering and potential groundwater contamination

**West Angelas Minesite - Ghost Bat Monitoring Survey** **2001**

Internal reference: RTIO-HSE-0014000

*Report documenting surveys were undertaken of known Ghost Bat roosting sites to determine the distribution and abundance of Ghost Bats within the caves located within the mine area. Caves surveyed were located within Deposit B and F as well as the eastern side of West Angelas Hill. A search for potential bat habitats was also conducted on the southern boundary of Deposit B and in a small gully between Deposit B and G that had not previously been investigated.*

Recent activity of Ghost Bats were recorded in three out of five caves. No Ghosts Bats were present in any caves searched. Summary of completed manangement actions in regards to the Ghost Bat management plan and planned future actions.

**West Angelas Stygofauna Assessment Survey** **2002**

Internal reference: RTIO-HSE-0016003

*A re-survey of stygofauna in the Turee Creek borefields and the Jeerinah Formation, within the West Angelas lease area. A total of 20 bores were investigated for their sampling potential. Of the 20 bores investigated only 12 were successfully sampled.*

Stygofauna were found in five bores. Up to five major groups were recognised from a single bore location. Bore WB51 revelased representative Amphipods, Copepods, Syncarids, Tubellarians and possibly Isopods. Bore WB54 contained potentially two species of Amphipod, one Copepod species and one species of Tubellarian worm. Copepods were the most commonly recorded stygofaunal group with 40 individuals collected from WB54 and 225 individuals observed in bore WB51. WB51 also revealed a large number of Tubellarian worms with 35 individuals recorded.

**West Angelas expansion deposits E & F subterranean fauna survey May 2004** **2004**

Internal reference: RTIO-HSE-0015937

*Report summarises findings of targeted stygofauna survey for E and F deposits of the West Angelas mining operation.*

A review of the geological units present in the valley system containing these deposits suggests that the area is not overly prospective for stygofauna. This is largely because the unit with greatest potential to provide habitat for stygofauna of those present, the superficial alluvials, is situated above the water table. There are also no significant calcrete systems present, which constitute core habitat for stygofauna in other parts of the Pilbara (Humphreys 1999). The deeper geological units that are saturated do not generally support stygal communities in most situations.

**Fauna habitats and fauna assembalges of deposit E and F at West Angelas June 2005** **2005**

Internal reference: RTIO-HSE-018209

*Robe River Iron Associates commissioned Biota Environmental Sciences to conduct a fauna survey of their Deposit E/F study area, adjacent to the existing operations at West Angelas. The survey was conducted over a 9-day period between the 4/5/2004 and 12/5/2004.*

Four primary habitats were identified within the project area: broad colluvial valleys, lower stony footslopes, stony hilltops, incised gullies and creeks. One fauna habitat is considered to have moderate conservation significance within the study area, based on the vegetation types. Broad colluvial valleys dominated by Acacia aneura (Mulga vegetation types M1-M5) comprise ecosystems at risk in the form of grove/intergrove and valley floor mulga. Two priority listed species were identified and one short range endemic (trapdoor spiders).

**Greater West Angelas Terrestrial Fauna Assessment, ecologia, January 2014** **2014**

Internal reference: RTIO-HSE-0215896

*This report details a baseline fauna survey of the Greater West Angelas study area deposits C, D, D extention, G, F, H and Mt Ella.*

Six mammal species (including Pilbara leaf nose bat), 12 bird species and three reptile species are listed as conservation significant. The literature review also identified 32 SRE species that have been previously recorded in the region surrounding the study area. A total of nine broad-scale habitat types have been identified within the study area; 'footslope or plain', 'hilltop, hillslope, ridge or cliff', 'mixed Acacia woodland', 'mesa top', 'cracking clay', 'major gorge and gully', 'major drainage', 'mulga woodland' and 'cleared area'. No habitats recorded were regarded as rare or unique to the study area.

## Biodiversity improvement studies

**Evaluation of mine waste materials as alternative rehabilitation growth medium** **2010**

Internal reference: RTIO-HSE-0109961

*This study reviewed the physical and chemical properties of soil, tailing and mineral waste from select Pilbara mining operations, to identify waste material and material combinations for use as a topsoil substitute or supplement.*

The study showed plant-available nutrients held within the waste materials, although variable, was characteristically low and comparable to natural soils in the region. The majority of the waste materials had macro and micro nutrient concentrations within the range or above the levels measured in benchmark Pilbara topsoil and rehabilitated soils. The pH and phosphorus buffering index of most waste materials were also comparable to that of the benchmark topsoil materials. However, some of the waste types and tailings may need to be mixed with rocky material due to poor physical / erodibility characteristics.

**Irrigated seed orchard trial** **2011**

Internal reference:

*Commencing in 2011 (and still ongoing), a trial irrigated seed orchard was established at the Hamersley Agriculture Project (Marandoo). The purpose of the trial was to identify an alternate method of addressing seed deficits. If successful, the project may be implemented at other Rio Tinto operations, such as the Nammuldi agriculture project.*

**Genetic diversity in Eucalyptus leucophloia across the Pilbara: Provenance zone implications** **2011**

Internal reference: RTIO-HSE-0108843

*This study was undertaken to define the provenance seed collection zones for a common species of the Pilbara, Eucalyptus leucophloia (Snappy Gum). This report details information on genetic analysis conducted on E. leucophloia. Collections of E. leucophloia were made from 20 populations across the Pilbara bioregion and genetic analysis was conducted using microsatellite markers.*

Genetic diversity in E. leucophloia was high and was typical of that found in other eucalypt species with wide spread distributions. Across the species the level of population differentiation was low and the majority of the diversity was maintained within populations with only 6% of variation partitioned between populations. Genetic variation in E. leucophloia showed little structure across the Pilbara with no clustering of populations based on any geographical proximity or in association with obvious topographical, physiogeographical or geological features such as the Hamersley or Chichester Ranges. Populations towards the edges of the species distribution within the Pilbara showed greater levels of differentiation from populations within the species main range. The high levels of genetic diversity and low levels of differentiation within E. leucophloia implies that seed resources for rehabilitation can be selected from a wide range within the Pilbara.

**Genetic diversity in Acacia ancistrocarpa across the Pilbara: Provenance zone implications** **2011**

Internal reference: RTIO-HSE-0119260

*This study was undertaken to define the provenance seed collection zones for Acacia ancistrocarpa (Fitzroy Wattle). This report details information on genetic analysis conducted on Acacia ancistrocarpa. Collections were made from 24 populations across the Pilbara bioregion and genetic analysis was conducted on 16 populations using microsatellite markers.*

Genetic diversity in A. ancistrocarpa was high but lower than that in E. leucophloia, another widespread species in the Pilbara. Across the species Pilbara range the level of population differentiation was low and the majority of the diversity was maintained within populations with only 3% of variation partitioned between populations. Genetic variation in A. ancistrocarpa showed little structure across the Pilbara with no clustering of populations based on geographical proximity or in association with obvious topographical, physiogeographical or geological features. Populations towards the edges of the species distribution within the Pilbara showed greater levels of differentiation from populations within the species main range. The high levels of genetic diversity and low levels of differentiation within A. ancistrocarpa implies that seed resources for land rehabilitation and mine-site revegetation programs can be selected from a wide range within the Pilbara

**Baseline Terrestrial Fauna Assessment of Pilbara Rehabilitation Areas** **2012**

Internal reference: RTIO-HSE-0134168

*In 2011 a fauna survey was conducted within established rehabilitation areas at Brockman 2 and Tom Price mine sites, with the aim of identifying whether fauna is recolonising rehabilitation sites in assemblages comparable to reference sites.*

The study found that at least 85 species of native vertebrate fauna, as well as representatives from each of six major groups of invertebrate fauna, are using rehabilitation areas at Brockman 2 and Tom Price, with species compositions that were broadly similar to reference sites. Ant collections were typical of the Pilbara bioregion, with an absence of invasive ant species. The study found greater data correlation between monitoring sites at a particular mine site (Tom Price or Brockman 2) than between rehabilitation and reference sites, indicating the importance of selecting local reference sites. The study concluded that the best candidates for bio-indicators are ants and reptiles.

**Rehabilitation Quality Metric (RQM) Project** **2012**

Internal reference: RTIO-HSE-0164020

*Western Australia has no formal process to measure habitat quality and as such RTIO has needed to design its own customised metrics. Vegetation condition scoring has previously been developed by RTIO through a Biodiversity Net Positive Impact Assessment, but a more precise metric was needed. The Rehabilitation Quality Metric (RQM) project was developed to provide a repeatable method to assess rehabilitation quality against pre-determined reference sites, on a site by site basis, to predict rehabilitation ecosystem quality at the time of relinquishment.*

The RQM methodology employs seventeen parameters to characterise the landscape, including vegetation, fauna habitat, fauna presence, erosion, and ecosystem function. Parameters are tailored to be an applicable measure for both rehabilitation and native vegetation (reference sites). Parameters are scored, based on measured or observed characteristics, with a value between 0 and 1, with 1 being functional (terrestrial ecosystem is functioning for the maintenance of biodiversity values at a local or property scale) and 0 being dysfunctional (terrestrial ecosystem is failing; indicators of ecosystem function have scored below acceptable levels). Both rehabilitation areas and reference sites are scored. Scores are subsequently determined for the entire mine lease, based on the condition of the land before mining (extrapolated from the reference sites, area weighted) and the likely post-mining conditions (extrapolated from the rehabilitation areas and expected closure domain distribution, area weighted, ie pits with no rehabilitation score 0). The difference between the pre-mining and post-mining scores represents the residual impact of mining.

**Propagation of Pilbara spinifex (Triodia sp.)** **2012**

Internal reference: RTIO-HSE-0169744

*Triodia has often been observed to have very poor establishment from broadcast seed. This project investigated alternatives to growing Triodia (spinifex) from seed, focussing on ways to propagate seedlings from wild harvested material.*

The project found the most successful propagating material was stolons. Greatest propagation success was achieved when Triodia were collected when semi to fully dormant (mid Winter-Spring). The ‘Moist Root Induction Method’ recommended by previous researchers was less successful than the standard propagation techniques employed in this project. Success varied notably between populations. Consequently, any future collections of propagating material should target multiple populations to maximise potential for success.

**Pilbara Seed Science Project, Part 2 Final Report Jan 2012** **2013**

Internal reference: RTIO-HSE-0174944

*Undertaken between 2009-2012, this seed research investigated germination, biology, dormancy classification and treatments for dormancy alleviation for a range of species from the Pilbara.*

The *Acacia atkinsiana, Indigofera monophylla and Sida echinocarpa* seed lots have physical dormancy. Heat treatments and mechanical scarification improved germination on dormant seeds, however, heat treatments killed non-dormant seeds. The treatments used for *Goodenia stobbsiana* seeds failed to overcome dormancy, suggesting deep physiological dormancy. The *Hakea lorea/ chordophylla* seed lots were found to be non-dormant, with very high germination results in the controls. As such, they will not require any pre-treatments prior to direct seeding. The florets surrounding the *Triodia pungens* and *T. wiseana* seeds were found to restrict germination, however, many of the freshly extracted seeds out of the florets were found to be physiologically dormant. Treatments for dormancy include mechanical scarifier to rupture seed coat, hot water (noting potential damage to immature or non-dormant seeds) and increases to germination through wet / dry cycling and / or temperature cycling.

**Priority Species Seed Quality and Germination Final Report** **2013**

Internal reference: RTIO-HSE-0207487

*This study investigated the quality and germination biology of a range of priority and keystone (Triodia) plant species from the Pilbara.*

Eremophila magnifica subsp. Magnifica has physical & physiological dormancy. Propagation methods other than seed may be more successful. Geijera salicifolia and Olearia mucronata has physiological dormancy. Temperature cycling may be required to stimulate germination. Indigofera ixiocarpa and Indigofera sp. Bungaroo Creek has physical dormancy or is non-dormant. Mechanical scarification may be required. Ptilotus subspinescens is non-dormant and will germinate easily without removal from the perianth sheath. However, seed is likely to lose viability with a few years. Sida echinocarpa and Sida sp. Barlee Range has physical dormancy. Seeds should be removed from the mericarp and then scarified in order to germinate. Triodia pungens has T. wiseana non-deeep or deep physiological dormancy. Germination of de-husked seeds can be improved by applying gibberellic acid or 1% smoke water and wet/dry cycling.

**Priority Species Project Progress Report 2013** **2014**

Internal reference: RTIO-HSE-0207486

*The Priority Species Project, initiated in 2012, aims to improve knowledge of priority plant species and develop methods to successfully germinate and establish priority species, to enable priority plant species to be integrated into Rio Tinto rehabilitation programmes. This work is being undertaken in conjunction with the Department of Parks and Wildlife.*

13 plant species were selected as being potentially suitable for establishment in rehabilitation: Eremophila magnifica subsp. magnifica, Indigofera sp. Bungaroo Creek, Indigofera sp. gilesii, Acacia bromilowiana, Sida sp. Barlee Range, Ptilotus subspinescens, Ptilotus mollis, Acacia subtiliformis, Isotropis parviflora, Grevillea sp. Turee, Hibiscus sp. Canga, Themeda sp. Hamersley Station, and Aluta quadrata. Indigofera sp. Bungaroo Creek and Ptilotus subspinescens were found to readily germinate in laboratory conditions, and a field trial was established at Brockman 4 late in 2013.

## Landform design

**Results of flume investigations of the stability of rock mulches** **1998**

Internal reference: RTIO-HSE-0109221

*This study assessed the potential for rock mulches to be stripped from the soil surface by overland flows.*

Although 150-300mm diameter BIF was not removed by simulated overland flows, even for 100mm/hr simulated runoff on 55% gradients, considerable scour of the spoil between the rocks was observed, indicating potential for long-term development of rills or gullies if the level of rock cover was less than 100%. Large reductions in sediment concentrations were observed when finer rocks were mixed with BIF. The data indicate that it is crucial for any rock mulch to cover a wide range of particle diameters, including a component of finer rocks. The resulting mixed rock created a framework of large rocks that resist movement by flows, while the smaller rocks reduce erosion being anchored within the larger (framework) rock. For rock mulches with a mixture of rock diameters, 80% cover produced acceptable erosion rates. Sediment loads were slightly higher for 40% cover by rock of mixed diameters, and it was speculated that this may also achieve acceptable erosion rates with the addition of vegetation.

**Final Landform Design Criteria for Use During Mine Planning** **2012**

Internal reference: RTIO-PDE-0159989

*Rio Tinto Iron Ore WA have historically designed closure landforms for waste materials with berms ~10 m, lifts ~20 m and ad hoc alterations to batter gradients where erosion rates have been perceived to be unacceptably high. This report integrates recent advances in characterisation and modelling of materials, climate and erosion processes to provide appropriate final landform batter characteristics for key Pilbara mineral wastes and soils.*

Material properties of mineral wastes were assessed and classified for the range of mineral wastes found across Rio Tinto Pilbara sites. Climate sequences were used to model and test potential erosion rates for a range of batter configurations (shapes (linear, concave), heights, gradients, berm capacity) and validated against existing slopes for which material and climate data were available. This information was used to develop a searchable waste dump batter database for all major mineral wastes and soils, intended for use during mine planning design.

## Contamination

**Impact of Nitrogen from Explosives on Mine Site Water Quality** **2008**

Internal reference: RTIO-PDE-0054638

*The likely issues associated with the use of nitrogen based explosives on mineral waste and any leachate water are explored in this report. The amounts of explosives used on site are described, along with nitrogen chemistry and toxicity. Nitrogen concentrations for various mine sites and specific lithologies are presented which includes concentration in rock assays and liquid extracts.*

It was concluded that the largest risk of nitrogen contamination is likely to arise from the discharge of surface waters that have been in contact with blasted materials and are discharged off site into creeks or waterways. This becomes a more significant issue if the water is also acidic. Algae (ie cyanobacteria) plumes have been identified in acidic water at Tom Price

**West Angelas Preliminary Site Investigation Report** **2008**

Internal reference: RTIO-HSE-0058441

*The purpose of this preliminary site investigation was to identify areas of potential environmental concern associated with current and historical activities at the site.*

Results from the risk ranking analysis show that in terms of overall risk factor, no "high risk" areas were identified at the site. The rail refuelling area, the diesel pipeline, the former landfill and the vehicle wash-down facilities were assessed to be of "moderate high" to "moderate low" risk. No previous environmental investigations have been undertaken at any of the facilities, these areas are potential areas of concern and have yet to be quantified. In all cases visual and/or anecdotal evidence suggested that potential adverse impacts to soil, groundwater or surface water, be it fuel spills, leaks or ongoing run-off/infiltration has historically occurred at these locations. For each of these areas of concern, a soil and groundwater sampling and analysis plan should be developed.

**Control Measures for Potentially Acid Forming Pit Wall Rocks** **2010**

Internal reference: RTIO-PDE-0079541

*Desktop study of potential strategies to manage exposed sulfidic materials and find viable options for management was conducted with a focus on the Hope Downs 1 and Tom Price sites.*

Chemical treatments have the potential to be effective only in the short-term and only for minor water quality issues. Grouting of the pit walls is expected to have limited applicability, although grout curtains behind the wall may have success (untested). Cover technologies have the greatest potential to be effective over the long term, but would need to be resistant to puncture by underlying rocks, resistant to weathering and UV damage ie shotcrete, geomembranes. For long term performance the exposed surface need to be as stable and free of loose material as possible. Treatment effectiveness will also depend on the site conditions, eg chemical less effective at Tom Price.

**Workshop Summary and Desktop Review: Dewatering and Sulfate Accumulation** **2012**

Internal reference: RTIO-PDE-0101903

*This is a summary of a workshop held to determine the risks of dewatering sulphides within the pit wall. The outcomes from this workshop will be used to develop models to estimate the mass of sulfate produced as a consequence of dewatering activities.*

There are many processes that contribute to poor pit water quality. Most of these processes are known and accounted for in existing models. However, the science of fluid flow in fractured rock is not well developed and this lack of knowledge restricts the outcomes of studies on pit water quality. There is a general lack of empirical data for estimating parameters used in models, creating a large degree of uncertainty in predictive models. Sensitivity analysis can be used to overcome some of these challenges.

**Contaminated Site Investigation - Soil and Liquid Waste Dumping Area at West Angeles** **2012**

Internal reference: RTIO-HSE-0142463

*This report investigats the recent increase in contaminated material placed in storage ponds and potential for infiltration to occur through soil stockpiles to groundwater.*

Results of the sampling concluded that there is minimal risk present at the area where the former contaminated stockpile was located. The remaining hydrocarbon concentrations are compliant with the ecological guidelines, with a few areas of elevated concentrations. Concentrations are expected to degrade over time, further reducing the potential for environmental impacts. A new bunded and graded cell has been created at the land farm. The area is expected to be suitable for rehabilitation.

**Updated Preliminary Site Investigation and Sampling and Analysis Plan for West Angelas Final** **2012**

Internal reference: RTIO-HSE-0148156

*The objectives of the project was to update existing information relating to known or suspected contamination at West Angelas and to subsequently develop a sampling and analysis plan in order to further characterise identified areas of interest.*

The review of the Preliminary Site Investigation found that, in general, the existing findings are accurate and have been carried out and presented in a manner consistent with the Department of Environment and Conservation Contaminated Sites Management Series. Additional areas of environmental concern were identified during the review. Areas of further interest presented in the sample and analysis plan are: 1) Mine Area - Rail refuelling area, former landfill, fire training ground, contaminated soils stockpile area, crusher area and the current mine landfill; and 2) Workshop / Administration Area - Light vehicle refuelling area, heavy vehicle refuelling area, heavy and light vehicle workshop area, heavy vehicle workshop area, light vehicle workshop areas, heavy and light vehicle wash-down facilities, bulk oils store, bulk fuels store, intermediate lube store, emergency power plant, recycling yard and the ammonium nitrate / fuel oil shed.

**Development of a conceptual model: Sulfate accumulation as a consequence of pit dewatering activities, memo** **2012**

Internal reference:
RTIO-PDE-0101903

*Mine dewatering and the consequent lowering of the water table may result in desaturation of sulfide bearing lithologies. The objective of this work was to develop a conceptual model of the associated processes: where sulphide bearing rock intersects the pit walls, and where the sulphide bearing rock is located behind the pit walls but not directly exposed on the pit wall face.*

The conceptual model developed estimates the mass of sulfate produced as a consequence of dewatering activities, considering processes during operations and after operations cease, and using sensitivity analysis where parameter inputs are uncertain. The model output provides the basis for an assessment of potential impacts on water quality for general risk assessment applications. Further work was identified to improve parameterisation of the model, including the collection of additional empirical data for pit wall fracturing, saturation of pit wall fractures and sulfide oxidation rates in talus and on pit walls.

## Ethnographic or archaeological values

**Water and Indigenous People in the Pilbara: A Preliminary Study, CSIRO: Water for a Healthy Country** **2011**

Internal reference:
RTIO-HSE-0218222

*Water resources are vital to Indigenous identities, beliefs, environmental philosophies and livelihoods. This report provides a broad-scale scoping study of Indigenous relationships to water in the Pilbara and considers the potential impacts of Indigenous water values.*

Indigenous belief systems perceive water as an elemental part of the broader cultural landscape, held and managed under customary systems of law. Water sources were derived during the Dreaming and are the most important features in the Pilbara cultural landscape. Interviews raised issues of long term drying, obstruction of water flow, over-extraction, inappropriate discharge from de-watering and access restrictions.

# West Angelas Deposits A west and F

# Subterranean Fauna Assessment

## 1. OVERVIEW OF SUBTERRANEAN FAUNA

Subterranean fauna tend to be highly specialised to, and obligate dwellers of, subterranean habitats. Subterranean fauna have been recorded from Western Australia since the 1940s. They are widespread in the Pilbara region and are generally considered to comprise two main categories (Humphreys 2000a in Biota 2004):

- Troglofauna: obligate terrestrial subterranean fauna occurring in underground cavities, fissures and interstitial spaces above the water table. Troglofauna are divided into three groups based on their life histories: troglobites, which are obligate dwellers of subterranean habitats; troglophiles, which are facultative species that live and reproduce underground but that are also found in similar microhabitats on the surface; and trogloxenes, which are principally surface species that regularly inhabit underground caves and cavities for refuge (Sket 2008). A fourth group; accidentals, wander into cave systems but cannot survive there (Howarth 1983 in *ecologia* 2013).

  A species is considered truly troglobitic if it displays morphological characteristics that appear to restrict it to subterranean habitats (Howarth 1983). These include a significant reduction or a complete loss of eyes, pigmentation and wings, as well as development of elongated appendages, slender body form and, in some species, a lower metabolism. Behavioural adaptations such as lack of a circadian rhythm (24-hour biological cycle) are also characteristic of true troglobites (*ecologia* 2013).

- Stygofauna: obligate groundwater-dwelling, aquatic fauna that occupy the interstitial spaces, vugs and fissures in alluvial, karstic or fractured rock aquifers. This environment is devoid of light, may have restricted available space and relatively constant temperature. These species have evolved unique features such as a lack of pigmentation, elongated appendages, filiform body shape (worm like) and reduced or absent eyes (*ecologia* 2013).

  Stygofauna, like troglofauna, are divided into three groups: stygobites which are obligate dwellers of groundwater and complete their entire life in this environment; stygophiles which inhabit both surface and subterranean aquatic environments, but are not necessarily restricted to either; and stygoxenes which are principally surface species with occasional presence in subterranean waters.

Higher levels of endemicity have been found to be characteristic of subterranean fauna (Biota 2004). The high levels of endemism that this fauna exhibit may be due, in part, to poor dispersal capabilities. The dispersal of fauna inhabiting subterranean environs is extremely slow and limited by the geological formation in which they occur (Marmonier et al. 1993; Gibert et al. 1994 in Biota 2004).

It is unclear at present whether the occurrence of subterranean fauna as documented by recent surveys in Western Australia reflect the true distribution of the fauna, and hence potential impact, or whether this is more a function of the current limitations on sampling and understanding of subterranean systems (Biota 2004). It is estimated that over 80% of the subterranean fauna likely to be present in Western Australia have not yet been documented (Guzik *et al*. 2010).

## 1.1 POTENTIAL IMPACTS

Recent surveys and research have suggested that relatively localised impacts such as mining have the potential to significantly change the conservation status of locally endemic species (Eberhard and Humphreys 1999; Biota 2001 in Biota 2004).

Potential impacts to subterranean fauna include the following:

- **Excavation**. Mining has the potential to reduce subterranean habitat availability.
- **Clearing**. The food resources for subterranean ecosystems are largely allochthonous, transported into subterranean habitats by water, plant roots and animals (Howarth 1983 in *ecologia* 2013). Clearing has the potential to reduce organic inputs to subterranean ecosystems.
- **Dewatering, groundwater abstraction and other aquifer impacts**. Dewatering has the potential to reduce habitat availability for stygofauna. Dewatering below troglofauna habitat may have the potential to impact subterranean humidity and therefore, the quality of troglofauna habitat. The extent to which humidity is affected by depth to the water table is unclear. Given that pockets of residual water probably remain trapped throughout de-watered areas (including within clay rich areas) and keep the overlying substrate saturated with water vapour, de-watering may have minimal impact on the humidity in the unsaturated zone. In addition, troglofauna may be able to avoid undesirable effects of a habitat drying out by moving deeper into the substrate if suitable habitat exists at depth.
- **Changes to surface hydrology**. Artificial landforms may cause localised reduction in rainfall recharge, and the associated input of dissolved organic matter and nutrients, to subterranean habitats. The input of organic matter and nutrients may be further reduced because the absence of surface leaf litter, which is considered to be the main source of carbon and nutrients. Reduced organic matter and nutrients are considered more likely to reduce population densities than cause extinction of species.
- **Vibration effects on subterranean habitats from blasting activities**. Blasting may have indirect effects on troglofauna through altering underground structure (usually via rock fragmentation which may result in either loss of habitat through collapse of voids or creation of habitat through fractures in bedrock).

However, these habitat effects are poorly quantified and their ecological consequences have not been described. Vibration is likely to dissipate rapidly with distance from the pit and blasting is not considered a significant impacting activity beyond the pit boundary.

- **Contamination** (e.g. pollutant spills). Contamination of soil or groundwater has the potential to reduce the quality of subterranean fauna habitat. Any contamination is likely to be localised and is not considered a significant impacting activity.

## 1.2 GUIDANCE ON ASSESSMENT

Given the considerable scientific interest in subterranean fauna, and the fact that a high proportion of subterranean species are short-range endemics (**SRE**), the Environmental Protection Authority (**EPA**) usually requires that risks to subterranean fauna are considered when assessing proposed mine developments where subterranean fauna are likely to occur (EPA 2003). The EPA has provided three Guidance Statements: Guidance Statement No. 54 - *Consideration of Subterranean Fauna in Groundwater and Caves during Environmental Impact Assessment in Western Australia* (EPA 2003), EPA Technical Appendix to Guidance Statement No. 54: *Sampling Methods and Survey Considerations for Subterranean Fauna in Western Australia* (EPA 2007) and Environmental Assessment Guideline No. 12: *Consideration of Subterranean Fauna in Environmental Impact Assessment in WA* (EPA 2013).

## 1.3 IMPACT ASSESSMENT APPROACH

The EPA endorses the use of physical habitat as a surrogate for species distributions at a local scale where taxa remain poorly sampled as a result of survey limitations:

*"Where a reasonable amount of sampling is unlikely to reveal the full range of a species because of demonstrated low capture rates in the habitat sampled, surrogates can be used to estimate whether the habitat is restricted… A physical surrogate is the use of habitat, known to support a particular species, to infer the likely presence of that species in the same habitat beyond the area surveyed. A physical surrogate can be used only where continuity of the presumed habitat can be clearly demonstrated with site-specific data. (Pages 13 and 14, EPA 2013)"*

Development of West Angelas Deposits A west and F are examples where sufficient sampling has occurred but subterranean fauna taxa distributions at the local scale remain poorly resolved as a result of low capture rates. Low specimen capture rates mean it is difficult to assess the impact of the project directly on the subterranean taxa collected. Thus Rio Tinto will infer the impact of the Proposal to subterranean fauna from the impact to the subterranean fauna habitat.

The below sections justify this approach by:

a) outlining the adequacy of current sampling;

b) characterising the habitat; and

c) examining the significance of Proposal related impacts to the identified habitat.

## 2. SUBTERRANEAN FAUNA SAMPLING

Subterranean fauna surveys have been undertaken over the entire West Angelas area since 1998. The following surveys are applicable to the Proposal;

- a baseline survey was conducted by Ecologia Environmental Consultants (*ecologia*) during 1998;
- a monitoring survey was undertaken by *ecologia* in 2002;
- a monitoring survey was undertaken by Biota in 2003;
- a baseline survey of Deposits E and F was conducted by Biota in 2004;
- a monitoring survey was undertaken by Biota in 2008;
- a monitoring survey was undertaken by Biota in 2012; and
- a subterranean fauna assessment survey was undertaken by *ecologia* in 2013.

A summary of the surveys is included in Sections 2.1 to 2.6.

### 2.1 BASELINE STYGOFAUNA SAMPLING (ECOLOGIA 1998)

The baseline stygofauna survey in 1998 was carried out by *ecologia* in collaboration with Western Australian Museum staff, and comprised a survey of the West Angelas borefield and the then proposed Turee Creek B borefield (*ecologia* 1998).

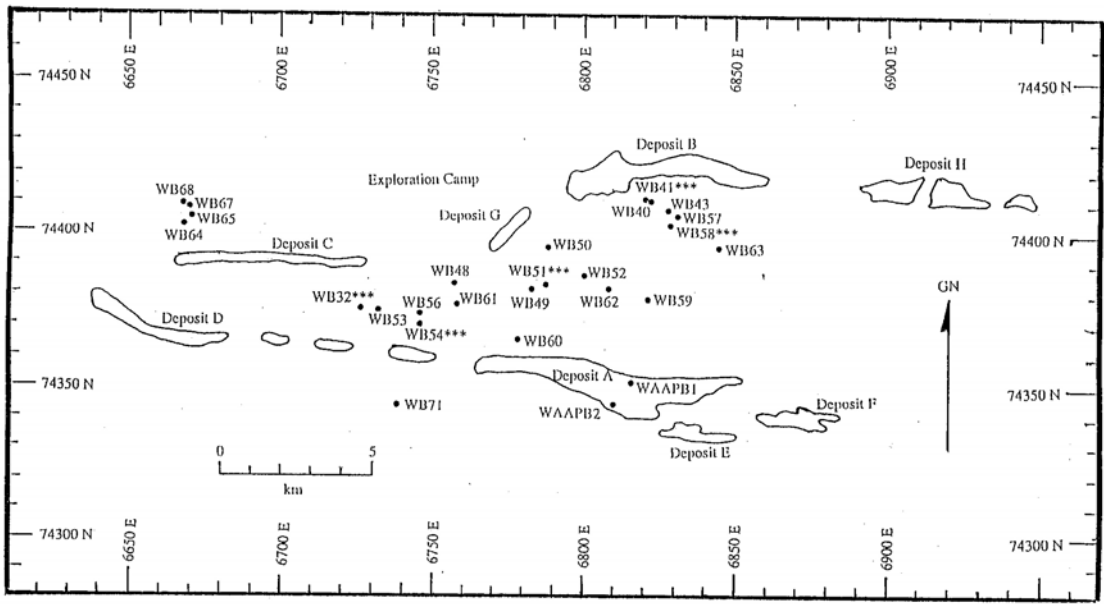
The survey sampled 44 bores in both the West Angelas and Turee Creek B borefields. Methods used include plankton haul nets and baited traps.

The survey resulted in the collection of stygofauna from six of the 44 bores (*ecologia* 1998). No troglofauna by-catch was collected. Analyses of the bore lithology concluded that there was a range of geologies in the area, and while calcrete is well known to be an important habitat for stygofauna (Marmonier et al. 1993, Eberhard 1998), the majority of the calcretes in the area were unsaturated (*ecologia* 1998). Instead, it was proposed that the stygofauna were utilising secondary habitats in other geologies. It was thought that the stygofauna were utilising fractures and weathered zones in the pockets of compact, non-permeable dolerite rocks as habitat. These habitats are patchily distributed, which led to a conclusion that the stygofauna distribution may be patchy within the area (*ecologia* 1998).

### 2.2 MONITORING SURVEYS (ECOLOGIA 2002, 2003)

Monitoring surveys were carried out in March 2002 and November 2003 and addressed the same areas as the baseline survey but sampled less bores (13 bores and 30 bores respectively) (*ecologia*, 2002).

Stygofauna were recovered from six of the 13 bores sampled in 2002 and six of the 24 bores sampled in 2003 (Figure 1). No troglofauna by-catch was collected.




Stygofauna indicated by ***

**Figure 1.** Locations of West Angelas Bores (sourced from Eberhard 1998 in Biota 2002).

Accordingly, borehole geology logs were sourced from the hydrogeology reports of Woodward Clyde (1997, 1998) and Aquaterra (1999, 2001). Bore logs were available for nine of the 13 bores that have yielded stygofauna (Table 1).

*ecologia* (2003) articulated the following conclusions about the presence of stygofauna and stygofauna habitat in the West Angelas and Turee Creek B borefields: stygofauna habitat has been identified previously in calcretes, unconsolidated material such as alluvium (especially coarse gravels) and fractured rock. Of the bores that yielded stygofauna, WB41, WB51 and WB54 in the West Angelas borefield have consistently had the most abundant and diverse collections. These three bores are of the greatest potential significance and sample optimal stygofauna habitat; they are open to similar geology types, consisting primarily of fractured dolerites and shales, with some shallow calcretes. Other bores where stygofauna have been collected included WOB12 (cased with slotting open primarily to alluvial geology); WOB1 and WOB9 (gravelly pisolites and goethite); WOB5 (BIF and jaspilite); and WOB22 (fractured volcanics/dolerite) in the Turee Creek B borefield. Stygofauna abundance was low in these bores however and it is likely that these do not intersect optimal stygofauna habitat compared to the geology intersected by WB41, WB51 and WB54.

**Table 1.** Borehole geology logs of bores where stygofauna have been recovered during all stygofauna surveys at West Angelas (data from Woodward Clyde (1997, 1998), ecologia (1998) and Aquaterra (1999, 2001) in Biota 2003).

| Borefield | Bore | Geological description |
|---|---|---|
| Other | Pastoral Bore (Blair's Bore) | Not available |
| West Angelas | WB32 | Not available |
| West Angelas | WB33 | Not available |
| West Angelas | WB40 | Not available |
| West Angelas | **WB41*** | Calcrete (0-12m), dolerite / calcrete (12-22m), dolerite (22-52m), dolerite / black shale (52-66m). |
| West Angelas | **WB51*** | Soil, clay and dolerite (0-10m), dolerite (fractured; 10-28m), dolerite and clay (28-38m), shale (38-70m) and dolerite (65-70m). |
| West Angelas | **WB54*** | Soil (0-5m), calcrete (5-10m), shale (10-22m), dolerite (22-60m) and dolerite / basalt / pyrite (60-85m). |
| West Angelas | WB58 | Soil and clay (0-5m), dolerite with fractures (5-85m). |
| Turee Creek | WOB1 | Scree (0-7m), clays (7-40m), gravelly pisolites and goethites (40-60m), goethite and limonite in a clay matrix, and jaspilite (60-86m). |
| Turee Creek | WOB12 | Recent - Tertiary alluvium (0-83m) above basement rock of BIF and jaspilitic BIF (83-90m). |
| Turee Creek | WOB22 | Sands and gravel (0-10m) underlain by clays (10-38m), basement gravels (38-44m) and fragmented volcanics / dolerite (44-64m). |
| Turee Creek | WOB5 | Alluvium (0-6m), and alluvium with clay (6-22m), gravelly goethites and limonite (22-32m), clays (32-62m), and scree (62-68m) above a basement of weathered jaspilitic BIF (Weeli Wolli). |
| Turee Creek | WOB9 | Alluvium (0-20m), gravelly scree and clay (20-48m), clays (48-74m), gravelly channel iron deposit (74-118m), underlain by clays and basement volcanics. |

***** bores have consistently yielded stygofauna

## 2.3 DEPOSITS E AND F SUBTERRANEAN FAUNA SURVEY (BIOTA 2004)

Stygofauna sampling at Deposits E and F in December 2003 was consistent with the approach outlined in EPA Guidance Statement Number 54 (EPA 2003).

A total of 12 bores were successfully sampled for stygofauna in the Deposit E area, and 8 bores were sampled in the Deposit F area. No stygofauna or troglofauna by-catch were recorded from any of the bores sampled during the survey. Many of the bores showed high turbidity and the geology of the sampled areas was not overly prospective for subterranean fauna (Biota 2004).

A review of the geological units present in the valley system containing these deposits suggests that the area is not overly prospective for stygofauna. The strata of boreholes previously sampled in the Deposit E and F area (from surface to end of hole) typically comprised:

1. Alluvials (top ~50 m);
2. Goethite and shales (50 - 100 m);
3. Banded Iron Formation (BIF) (deeper layers, down to 130 m from top of hole).

In the inland Pilbara, the superficial alluvials are the only geological type that appear to consistently provide habitat for stygofauna (Biota unpublished data in Biota 2004). However, at Deposits E and F, this unit is situated above the water table (depth to water table is approximately 100 m below the ground level) and is largely unsaturated. The deeper geological units below the water table in the study area do not typically support stygal communities (Biota unpublished data, Humphreys 2000b in Biota 2004).

The Biota (2004) report did not consider the potential for the unsaturated superficial alluvial strata to contain troglofauna.

## 2.4 WEST ANGELAS AND DEPOSIT A STYGOFAUNA SURVEY (BIOTA 2008)

A single-phase stygofauna survey was completed in 2008 in accordance with EPA Guidance Statement No. 54 - *Consideration of Subterranean Fauna in Groundwater and Caves during Environmental Impact Assessment in Western Australia* (2003).

A total of 15 bores in the Deposit A aquifer were successfully sampled for stygofauna. No stygofauna or troglofauna by-catch were recorded from any of the bores sampled (Biota 2008a).

The Deposit A aquifer is described by Woodward-Clyde (1998) as variably permeable and is surrounded by low permeability material. The lack of stygofauna collected during the survey was considered consistent with the confined nature of this aquifer (Biota 2008a).

## 2.5 WEST ANGELAS STYGOFAUNA SURVEY (BIOTA 2012)

A single-phase stygofauna survey was completed in 2012 in accordance with EPA Guidance Statement No. 54 (EPA 2003), and EPA Technical Appendix to Guidance Statement No. 54: *Sampling Methods and Survey Considerations for Subterranean Fauna in Western Australia* (2007).

A total of 12 bores were successfully sampled for stygofauna, including 10 from the Turee Creek B borefield and two from the Deposit A aquifer. No stygofauna or troglofauna by-catch were recorded from either area in 2012 (Biota 2012).

Previous sampling of the Turee Creek B borefield has yielded 30 stygofauna specimens in total. Twenty-two of the total specimens recorded came from a single site (WOB12) during 2002, which later that year yielded no stygofauna (Biota 2003). While no stygofauna were collected during the 2012 phase of sampling, it was impossible to conclusively determine whether this represents a natural fluctuation in stygal populations or a project-induced impact (Biota 2012).

No stygofauna have been collected from within the confined aquifer at Deposit A to date (including prior to dewatering of the deposit). The lack of stygofauna collected was considered consistent with the confined and disconnected nature of this aquifer (Biota 2012), as described in Section 2.4.

## 2.6 GREATER WEST ANGELAS SUBTERRANEAN FAUNA SURVEY (ECOLOGIA 2013)

The most recent single-phase subterranean fauna (troglofauna and stygofauna) survey was conducted in accordance with EPA Guidance Statement No. 54 (EPA 2003), and EPA Technical Appendix to Guidance Statement No. 54 (EPA 2007).

A total of 91 drill holes were sampled for troglofauna. Only twenty two bores (24%) intercepted ground water, with the remaining holes above the water table.

The survey yielded 109 invertebrate specimens representing eleven orders. Of these, ten species were identified as troglobitic. These species belong to the orders; Thysanura (silverfish), Psocoptera (booklice), Hemiptera (true bugs), Embioptera (webspinners), Blattodea (cockroaches), Coleoptera (beetles), Araneae (spiders), Isopoda (slaters) and Chilopoda (centipedes). Non-troglobitic specimens included Collembola (springtails), Blattodea, Coleoptera, Araneae and Diplopoda (millipedes). Troglobitic specimens collected are summarised in Table 2 and mapped in Figure 2.

The likelihood of the collected troglobitic species to be considered SRE was determined by expert taxonomists based on the current knowledge of the distribution and biology of each species. Six of the recorded species (*Nocticola* sp. indet., *Prethopalpus* sp. indet., *Pseudodiploexochus* sp. nov., *Cormocephalus* CH1003, *Atelurinae* sp., indet., Anillini sp.indet.) are considered likely to have restricted distribution ranges and four (*Hydrobiomorpha* sp. indet., *Embioptera* sp. indet., Meenoplidae sp. indet., Trogiidae sp. indet.) are potentially restricted. Only spiders of the genus *Prethopalpus* and centipedes from the genus *Cormocephalus* have been recorded previously in the area, with the remaining eight genera/families representing new records. In addition, the spider *Prethopalpus* 'sp indet.' and the isopod *Pseudodiploexochus* 'sp. nov.' (the first ever to be recorded in the Pilbara region at the time of the survey) represent new species. The centipede *Cormocephalus* 'HCI003' was the first eyeless scolopendrid specimen recorded at the time of the survey.

The majority of troglobitic species recorded were collected as singletons and doubletons, with only the Blattodea specimens (*Nocticola* sp. indet.) and Coleoptera specimens (*Anillini* sp. indet.) collected in higher numbers 13 and 26, respectively).

**Table 2.** Troglobitic specimens recorded (*ecologia* 2013).

| Order | Genus/Species | Easting | Northing | Bore ID | No. individuals |
|---|---|---|---|---|---|
| Thysanura | *Atelurinae* 'sp. indet.' | 667471 | 7436527 | WAD358 | 1 |
| Psocoptera | *Trogiidae* 'sp. indet.' | 691917 | 7441689 | DHRC006 | 1 |
| Hemiptera | *Meenoplidae* 'sp. indet.' | 677142 | 7439755 | WAG307 | 1 |
| Hemiptera | *Meenoplidae* 'sp. indet.' | 690832 | 7441805 | WAH189 | 1 |
| Embioptera | *Embioptera* 'sp. indet.' | 676945 | 7436109 | DExt13 | 1 |
| Blattodea | *Nocticola* 'sp. indet.' | 691491 | 7441209 | DHRC010 | 2 |
| Blattodea | *Nocticola* 'sp. indet.' | 690832 | 7441805 | WAH189 | 3 |
| Blattodea | *Nocticola* 'sp. indet.' | 693430 | 7441478 | WAH048 | 8 |
| Coleoptera | *Anillini* 'sp. indet'. | 672131 | 7439118 | WACRC332 | 26 |
| Coleoptera | *Hydrobiomorpha*'sp. indet.' | 665491 | 7437029 | WAD329 | 2 |
| Araneae | *Prethopalpus* 'sp indet.' | 693112 | 7441491 | WAH017 | 2 |
| Isopoda | *Pseudodiploexochus* 'sp. nov.' | 693112 | 7441491 | WAH017 | 2 |
| Chilopoda | *Cormocephalus* 'CHI003' | 690369 | 7441601 | WAH192 | 1 |

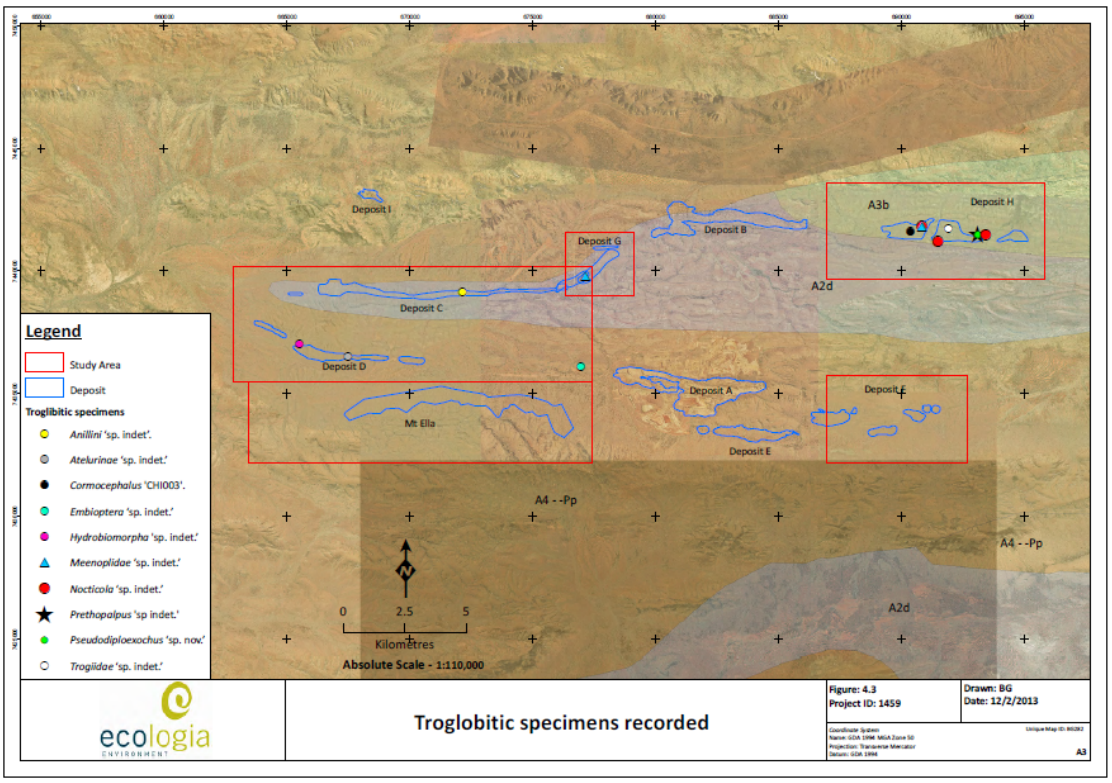



**Figure 2.** Troglofauna specimens recorded (*ecologia* 2013).

There was little commonality of troglofauna species across different geological units, suggesting potentially isolated species assemblages. However, this is considered likely to be an artefact of a small sample size.

Only one of the potentially troglobitic species recorded by *ecologia* in 2013, *Embioptera* sp. indet, is associated with the Proposal. A single juvenile specimen was collected from a bore in Deposit A west. Classification to family level was not possible because only adult males can be taxonomically identified. Little is known about troglobitic *Embioptera*. Generally they have limited distribution due to the flightless nature of the females, and morphologically distinct groups appear to be geographically restricted. This species is thus considered to represent a potential SRE.

Stygofauna sampling was limited to four accessible bores in Deposit F, which yielded no stygofauna specimens.

## 3. SPECIES ASSESSMENT

Over the span of the historical surveys, troglofauna were only recovered in the most recent survey. The majority of potentially troglobitic species recorded were collected as singletons, i.e. known only from a single individual at a single location. Most of the species are therefore known only from within the Proposal Area.

Over the span of the historical surveys stygofauna were recovered from bores within both the Turee Creek B borefield and the West Angelas borefield. The majority of potentially stygobitic species were collected in low abundance.

It is estimated that 70% of Pilbara stygofauna species are SREs (Eberhard *et al*. 2009).The proportion of SRE troglofauna in the Pilbara is likely to be significantly higher, given that the known ranges of many troglofauna are smaller than those of stygofauna (Lamoreux 2004).

However, it is considered unlikely that the species currently known only from a few records do, in fact, have such restricted ranges. The known ranges of most 'restricted' species are thought likely to be an underestimate given that information on the range of subterranean fauna species is limited to the point where they are known occur.

The specific identification, distribution and conservation status of the *Embioptera* sp. indet collected remains undefined. However, it is considered probable that the range of this 'restricted' species extends in continuous habitat. Evidence about the likely distributions of species in continuous habitat at West Angelas is included in the habitat assessment below.

## 4. HABITAT CHARACTERISATION

The occurrence and distribution of subterranean fauna is influenced or limited by the geological formation in which they occur. The presence of subterranean voids affects the pattern of occurrence, the density and distribution of subterranean fauna. Lateral connectivity of voids is important because it enables animals to move about underground, while vertical connectivity with the surface is important for supplying carbon and nutrients to maintain populations of different species. Geological features such as major faults can either act as barriers or conduits to below-ground dispersal of subterranean fauna.

### 4.1 GEOLOGY OF THE PILBARA

The geology of the Pilbara region is dominated by the Hamersley Group. The Hamersley Group was formed by chemical sedimentation of minerals in an ocean environment during the late Archean and early Proterozoic (2,500 million years ago). It contains several large units of alternating iron-rich and silica-rich layers called banded iron formation (BIF). The BIF derived ore group contains the largest tonnage of known iron ore resources (Hamersley Iron, 2000).

### 4.2 GEOLOGY OF THE WEST ANGELAS REGION

The West Angelas deposits are located on the regional Wonmunna Anticline. The geological formations in this local synclinal structure are continuous, extending throughout the region.

The Wonmunna anticline contains a low-lying plateau of Jeerinah Formation in its core. The composition of the Jeerinah Formation includes mudstones, shales, and ultramafic intrusive dolerite sills. The permeability and groundwater storage is generally low in this formation, except where there are local fracture systems associated with regional lineaments. Areas of low relief have been in filled with Tertiary and Quaternary sediments, up to 70 m thick, and include boulder beds and gravel, calcrete and silcrete, mixed sand and gravel and Channel Iron Deposit (Pisolite) (*ecologia* 1998; Hamersley Iron 2000).

The Marra Mamba Iron Formation surrounds the Jeerinah Formation. The Marra Mamba Iron Formation is subdivided into three members. The main unit of interest within the Marra Mamba Iron Formation is the uppermost Mt Newman Member which hosts the majority of mineralisation at West Angelas. The Mt Newman Member comprises banded iron formation (BIF) with interbedded carbonate and discrete shale bands.

Mineralisation consists of a series of discontinuous deposits located on both the north and south limb of the regional anticline. Along the northern limb of the regional anticline (from west to east) are deposits C, G, B and H while the southern limb hosts (from west to east) Deposits D, A, E and F (*ecologia* 1998).

The mineralisation is overlain by a widespread regolith of hydrated material, produced by the secondary alteration process of weathering. This hydrated material, which is commonly intersected in the Mount Newman Member close to the surface, is generally 20 – 50 m thick.

### 4.2.1 Deposit A west

Deposit A west is a southerly dipping Marra Mamba resource occurring along the southern limb of the regional Wonmunna Anticline. The deposit is east-west trending over a strike length of 9 km, with the eastern end terminating at Deposit A, and is considered a continuation of the mineralisation.

Mineralisation is predominately contained in the Mt Newman Member of the Marra Mamba Iron Formation. There is also minor mineralisation in the MacLeod Member and at the base of the West Angelas Shale Member. Dolerite dykes are present throughout the deposit.

Hydrated detritals cover the resource. These detritals are generally pisolitic or limonitic in lithology.

### 4.2.2 Deposit F

Deposit F also occurs along the southern limb of the regional Wonmunna Anticline. The deposit is considered a continuation of the Deposit E mineralisation, with an interrupted resource approximately 6 km in strike length. The Deposit F resource includes Marra Mamba and Detrital mineralisation.

Mineralisation is predominately contained in the Mt Newman Member and sometimes into the Macleod Member. Where present, the lower part of the West Angelas Member may also be mineralised. Faults are present throughout the deposit. Detritals intermittently overlay the bedrock, creating continuous, variably thick, mineralisation which transitions down into the mineralised Mount Newman Member.

Alluvials cover the resource, varying from 2 metres in depth in the north to up to 80 metres towards the south.

## 4.3 LOCAL HABITAT ASSESSMENT

The occurrence and distribution of subterranean fauna is influenced or limited by the geological formation in which they occur. Such dispersal limitations result in extremely small, fragmented species ranges and thus high levels of endemism (EPA 2003). In order to assess the potential for subterranean fauna to occur, it is necessary to identify likely habitats and the extent of those habitats:

### 4.3.1 Troglofauna

The range of geological formations which troglofauna may habit has yet to be determined, however, surveys have demonstrated that troglofauna occur within various rock-forms of the Pilbara. Troglofauna are most commonly associated with calcrete deposits, likely due to

their karstic nature which creates habitat space in the form of caves, together with interconnectivity. More recently they have also been associated with micro-cavities of porous Pisolite Iron Formations and BIF within the Pilbara, which contain cavities of various sizes. The micro-habitats within these lithologies are yet to be characterised but it is inferred they occupy fissures and voids associated with weathering and faulting.

The Marra Mamba Iron Formation is not considered core habitat for the persistence of significant populations of troglofauna. Deposits A west and F are considered 'typical' of Marra Mamba Iron Formation. The massive-textured geology of these deposits does not provide suitable interconnected cavities or void spaces, suggesting that the distribution of subterranean fauna is likely to be limited in this formation.

Moreover, this geological formation is well-represented in the region (

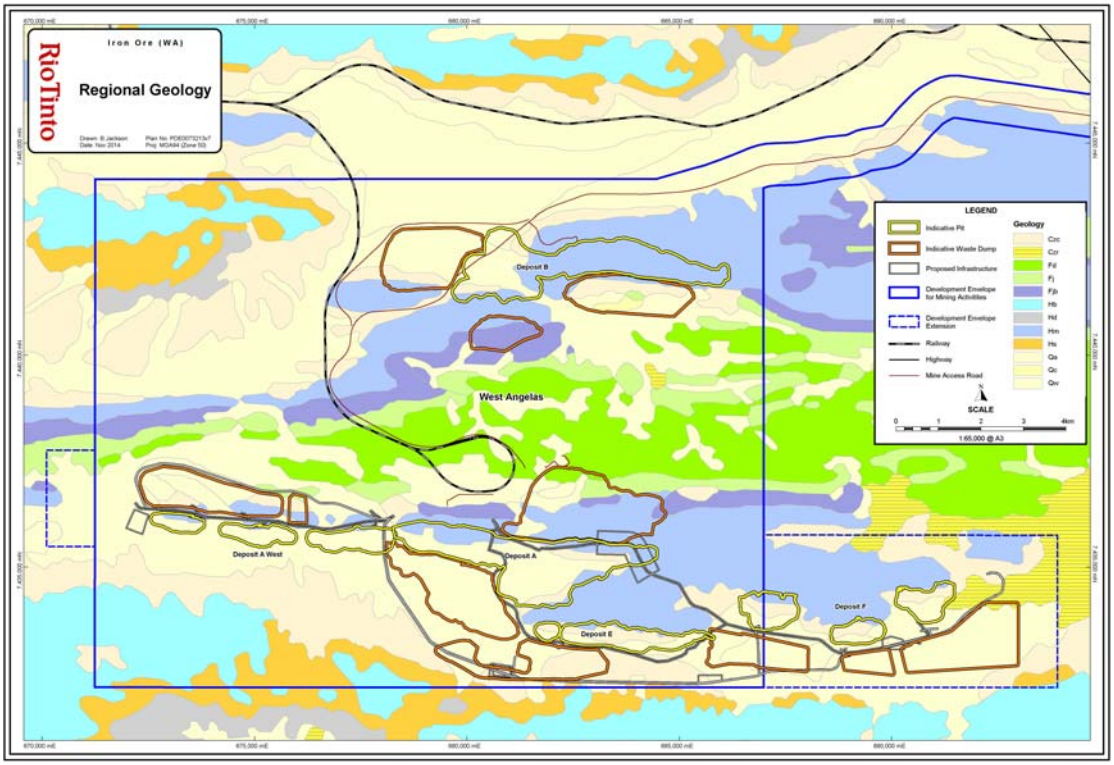



Figure **3**). Even if the sedimentary rocks of the Marra Mamba Iron Formation hosted some troglofauna, the proposed area of Marra Mamba Iron Formation affected by mining is negligible is comparison to the overall area of the formation present in the wider region.

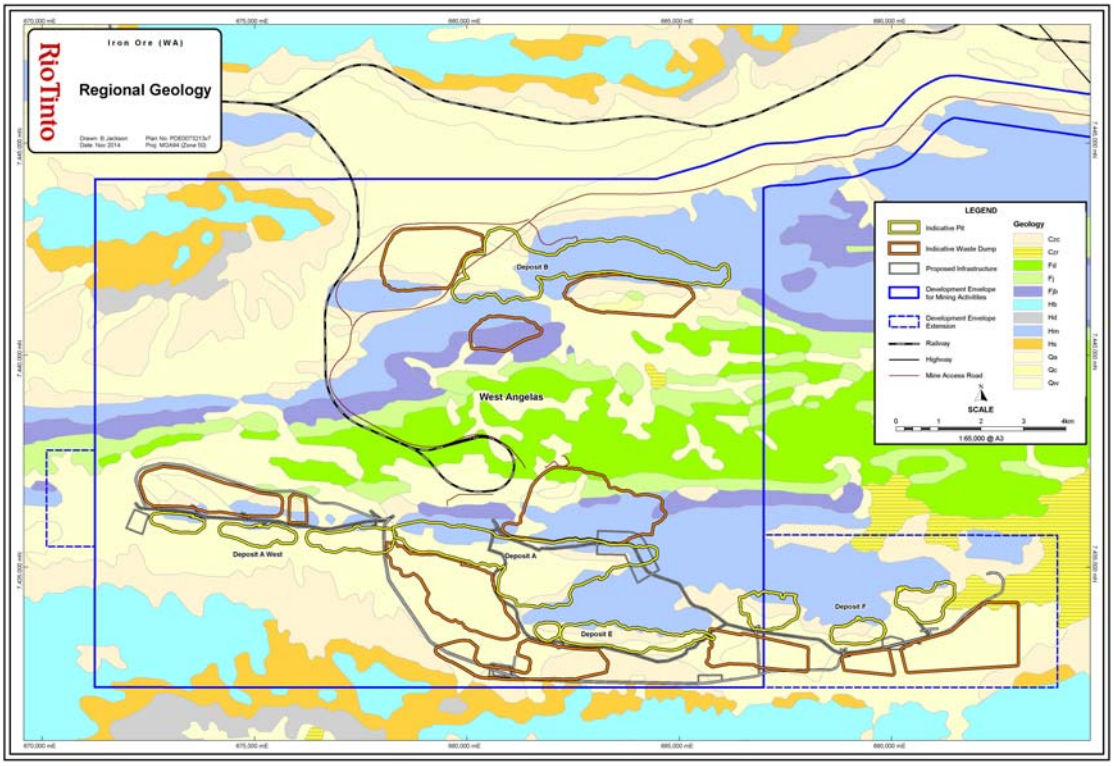



**Figure 3.** Geology.

Local fracture systems and weathered zones associated with regional lineaments are one of the only parts of the Marra Mamba Iron Formation which represent potential troglofauna habitat. These fractured and weathered zones exhibit vughy textures. The fracture patterns are not well defined and it is likely that they extend vertically and horizontally outside of the Proposal Area suggesting there is habitat continuity through areas where the species was not recorded. The degree of connectivity of these habitats is important for subterranean fauna dispersal. It may be reasonably expected that if troglofauna were present within are local fracture systems and weathered zones, then they would be well represented across the entire area.

Hydrated, vuggy-textured material has also previously been identified as potential troglofauna habitat elsewhere in the Pilbara. The widespread regolith of hydrated material, which is commonly intersected in the Mount Newman Member close to the surface, is the only other part of the formation which potentially can exhibit micro-vughy textures. Hydrated zones extend beyond the deposits (i.e. they occur both locally and regionally). It is therefore likely that troglofauna habitat extends into continuous habitat in the surrounding strata.

The deeper geological units that are saturated (below the water table) do not support troglofauna communities.

### 4.3.2 Stygofauna

The presence of stygofauna in Western Australia has been well documented, especially from regions such as the Pilbara and Kimberley, and less so in the Midwest and South West regions of Western Australia (*ecologia* 2013). Stygofauna are known to be present in the

groundwater associated with a variety of geologies. These include (but are not limited to) calcrete aquifers associated with palaeochannels, haematite sandstone aquifers, clay-sandstone aquifers on the Swan and Scott Coastal Plains, porous aquifers (e.g. alluvium), fractured-rock aquifers, springs and hyporheic habitats (*ecologia* 2013). These types of aquifers have sufficient interstitial spaces required to support stygofauna.

However, distribution patterns of stygofauna in aquifers are considered to be determined by hydraulic connectivity rather than associated with particular geologies. Stygofauna require adequate hydraulic connectivity to allow food and oxygen to be distributed from the surface to the groundwater.

Open (porous, fractured and karstic) aquifers have abundant interstitial space and at least moderate hydraulic conductivity. There is continuous exchange with surface water for food and oxygen supply, which is why stygofauna communities are often found in this aquifer type (Hahn and Fuchs 2009). Historically, the Turee Creek B borefield, which is located within an open aquifer, has yielded stygofauna (*ecologia* 2013).

Confined and / or compact aquifers have low hydraulic conductivity and are not considered overly prospective habitat for stygofauna according to classifications by the EPA (2013). These types of aquifers have minimal interstitial space and reduced food and oxygen supply, which is why these aquifer types are usually either devoid of stygofauna or have depleted taxonomic richness and abundance (Hahn and Fuchs 2009 in *ecologia* 2013). Historically, the Deposit A aquifer, which is a confined aquifer has returned no stygofauna (Biota 2003, 2008).

Given the depth and hydraulically confined nature of the Deposits A west and F aquifers, these aquifers are considered unlikely to support significant populations of stygofauna. This does not preclude the potential occurrence of stygofauna if the aquifers have secondary hydraulic conductivity in the form of local fractures. However, the historic sampling of the Deposit A, which failed to detect stygofauna, suggests there is a low likelihood of a diverse and abundant stygofauna community being present in these analogous aquifers.

## 5. SUMMARY

Based on review of potential subterranean habitats, results of published and unpublished studies on subterranean fauna from the region and previous subterranean fauna sampling, the Proposal generally presents a low risk to subterranean fauna:

- No species listed under the EPBC Act, WC Act or by the Department of Parks and Wildlife as critical, endangered or vulnerable have been recorded.
- Stygofauna have not historically been recorded from, and are not expected to be recorded from, within the confined (i.e. low hydraulic connectivity) aquifers associated with the deposits.
- The Proposal has the potential to impact the potentially locally endemic troglofauna *Embioptera* sp. indet which was collected from a bore in Deposit A west however, the known range of 'restricted' species, particularly those represented by a single specimen, is likely to be an underestimate. It is considered probable that the range of this 'restricted' species will extend in continuous habitat.

- Adequate sampling (as per EPA (2013)) has occurred. Low capture rates mean Rio Tinto is using habitat as a surrogate for the distribution of subterranean fauna taxa, as per the approach outlines in EPA (2013).
- The Marra Mamba Iron Formation is not considered core habitat for the persistence of significant populations of troglofauna. Moreover, even if the Marra Mamba Iron Formation hosted some troglofauna, the proposed area of Marra Mamba Iron Formation affected by mining is negligible is comparison to the continuous extent of Marra Mamba formation within the syncline and overall area of the formation present in the wider region.
- Local fracture systems and weathered zones as well as hydrated material, which represent potential troglofauna habitats both connect and extend outside of the deposits suggesting there is habitat continuity through areas where species were not recorded. It may be reasonably expected that if troglofauna were present, then they would be well represented within the local area.

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