TORO ENERGY LIMITED

WILUNA URANIUM PROJECT

EXTENSION TO THE WILUNA URANIUM PROJECT
ASSESSMENT NO: 2002 (CMS14025)
PUBLIC ENVIRONMENTAL REVIEW
NOVEMBER 2015

Toro Energy Limited

ABN 48 117 127 590

Level 3, 33 Richardson Street, West Perth, WA, 6005.

PROPOSAL:	**EXTENSION TO THE WILUNA URANIUM PROJECT**
ASSESSMENT NUMBER:	2002 (CMS 14025)
LOCATION:	Mining at two locations 30 kilometres south and 105 kilometres south-east of Wiluna, Western Australia
LOCALITY:	Shire of Wiluna
PROPONENT:	Toro Energy Limited
LEVEL OF ASSESSMENT:	Public Environmental Review with a 12 week public review
EPBC REFERENCE:	EPBC 2014/7138

DOCUMENT REF	REVISION	DATE	PREPARED BY	CHECKED	AUTHORIZED	AUTHORIZED FOR USE
	A					

Title: Extension to the Wiluna Uranium Project – Public Environmental Review

INVITATION

The Environmental Protection Authority (EPA) invites people to make a submission on this Proposal. The environmental impact assessment process is designed to be transparent and accountable, and includes specific points for public involvement, including opportunities for public review of environmental review documents. In releasing this document for public comment, the EPA advises that no decisions have been made to allow this proposal to be implemented.

The subject of this Public ENvironemntal Review (PER) is the proposal of Toro Energy Limited (Toro) to extend the Wiluna Uranium Project located near Wiluna, Western Australia through the mining of two deposits, **Millipede** and **Lake Maitland**, as well as the construction of a haul road and associated infrastructure.

The Wiluna Uranium Project was the subject of EPA Assessment 1819 (EPA Report 1437). Following this assessment, the Western Australian Minister for Environment gave Toro approval in October 2012 (Ministerial Statement No. 913) to construct and operate a uranium mine consisting of two deposits, **Centipede** and **Lake Way**, respectively located approximately 30 kilometres (km) south and 15 km south-east of Wiluna. The federal Minister for Sustainability, Environment, Water, Population and Communities also approved that proposal (EPBC 2009/5174) in April 2013. Toro has not yet commenced mining at Centipede and Lake Way.

Since initiating assessment of the Wiluna Uranium Project, Toro acquired two additional deposits, Millipede, also approximately 30 km south of Wiluna, and Lake Maitland, 105 km south-east of Wiluna, and proposes to integrate those deposits into an extended Wiluna Uranium Project.

Ore from Millipede and Lake Maitland would be processed at the same plant as ore from Centipede and Lake Way. The capacity of the processing plant already approved in EPA Assessment 1819 and EPBC 2009/5174 would not increase under this proposal to extend the Wiluna Uranium Project. Instead, the plant's operating life could extend beyond 20 years, the period during which sequential mining would be undertaken at the Centipede, Millipede, Lake Maitland and Lake Way deposits. During that period, the operation would produce up to 1200 tonnes per annum (tpa) of uranium oxide concentrate (UOC) – the current production limit approved under EPA Assessment 1819 and EPBC 2009/5174. Construction and pre-mining are scheduled to begin at Centipede by late 2016 and at Millipede at the same time, subject to government approval and market conditions.

A proposal for mining at Lake Maitland was the subject of EPA Assessment 1821 which had not been completed at the time Toro acquired ownership of Lake Maitland in November 2013. Toro has withdrawn that proposal because of its intention to change the project configuration.

In accordance with the *Environmental Protection Act 1986*, a PER document has been prepared which describes this proposal and its likely effects on the environment. The PER is available for a public review period of 12 weeks from **16 November 2015 to 8 February 2016**.

Comments from government agencies and from the public will help the EPA to prepare an assessment report in which it will make recommendations to government.

Where to get copies of the Public Environmental Review

Printed and CD copies of this document may be obtained from Ursula Price at Toro Energy Limited, Level 3, 33 Richardson Street, West Perth, Western Australia 6005 – phone + 61 8 9214 2100 or ordered by email at info@toroenergy.com.au. The cost for hard copies of the document is $10 (including postage and handling). CD copies are free of charge.

The document/s may be accessed directly from Toro Energy's website at: www.toroenergy.com.au.

Technical appendices to the PER are provided on CD with this document. The technical appendices are also available on Toro's website (www.toroenergy.com.au).

Why write a submission?

A submission is a way to provide information, express your opinion and put forward your suggested course of action—including any alternative approach. It is useful if you indicate any suggestions you have to improve the proposal.

All submissions received by the EPA will be acknowledged with electronic submissions being acknowledged electronically. The proponent will be required to provide adequate responses to points raised in submissions. In preparing its assessment report for the Minister for Environment, the EPA will consider the information in submissions, the proponent's responses and other relevant information. Submissions will be treated as public documents unless provided and received in confidence, subject to the requirements of the *Freedom of Information Act 1992*, and may be quoted in full or in part in the EPA's report.

Why not join a group?

If you prefer not to write your own submission, it may be worthwhile joining with a group or other groups interested in making a submission on similar issues. Joint submissions may help to reduce the workload for an individual or group, as well as increase the pool of ideas and information. If you form a small group (up to 10 people), please indicate all the names of the participants. If your group is larger, please indicate how many people your submission represents.

Developing a submission

You may agree or disagree with, or comment on, the general issues discussed in the PER or the specific proposal. It helps if you give reasons for your conclusions, supported by relevant data. You may make an important contribution by suggesting ways to make the proposal more environmentally acceptable.

When making comments on specific elements in the PER document:

- Clearly state your point of view;
- Indicate the source of your information or argument if this is applicable;
- Suggest recommendations, safeguards or alternatives.

Points to keep in mind

By keeping the following points in mind, you will make it easier for your submission to be analysed:

- Attempt to list points so that issues raised are clear. A summary of your submission is helpful;
- Refer each point to the appropriate section, chapter or recommendation in the PER;
- If you discuss different sections of the PER, keep them distinct and separate, so there is no confusion as to which section you are considering; and
- Attach any factual information you may wish to provide and give details of the source. Make sure your information is accurate.

Remember to include:

- Extension to the Wiluna Uranium Project and CMS14025;
- Your name;
- Address;
- Date; and
- Whether and the reason why you want your submission to be confidential.

The closing date for submissions is: **8 February 2016**.

The EPA prefers submissions to be made at: https://consultation.epa.wa.gov.au.

Alternatively, submissions can be:

- Posted to: Chairman, Environmental Protection Authority, Locked Bag 10, EAST PERTH WA 6892; or
- Delivered to the Environmental Protection Authority, Level 8, The Atrium, 168 St Georges Terrace, Perth.

If you have any questions on how to make a submission, please ring the Office of the Environmental Protection Authority on +61 8 6145 0800.

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Note – Appendices 10.53, 10.54 and 10.60 are draft reports. They were commissioned by the former owner of Lake Maitland and had not been finalised at the time Toro acquired Lake Maitland. However, each report contains extensive baseline data which remains relevant to an assessment of Toro's proposal for mining at Lake Maitland. Appendices 10.37 to 10.46 contain peer reviews of previous environmental investigations undertaken at Lake Maitland.

1 INTRODUCTION

1.1 Purpose and Scope

Toro Energy Limited (Toro) is proposing to extend the Wiluna Uranium Project (the Project) located approximately 960 km north-east of Perth in the Shire of Wiluna, Western Australia, to include the mining of two additional deposits known as Millipede and Lake Maitland.

This Public Environmental Review (PER) has been prepared as part of the process to seek state and federal approval for the Extension to the Wiluna Project (the Proposal) and is the key document for joint environmental assessment of the Proposal by the:

- Western Australian Environmental Protection Authority (EPA) and the Minister for Environment (the Minister) under the *Environmental Protection Act 1986* (WA); and
- Federal Department of the Environment (DoE) and the Minister for the Environment under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth).

The PER is also made available to the public to review the Proposal. Comments received from the public and government agencies during the public review period, and Toro's response to these comments, will assist the EPA in preparing an assessment report in which it will make recommendations to the Minister.

1.2 Document Structure

This PER provides:

- An overview of the Proposal and information about Toro;
- Discussion of the legislative and administrative framework that will apply to the assessment of the Proposal;
- An explanation of stakeholder and community consultation and engagement;
- Discussion of benefits of the Proposal and evaluation of alternatives;
- A detailed description of the Proposal;
- An outline of impact assessment methodology;
- A description of the existing environment in which the Proposal would be undertaken;
- An assessment of the Proposal's environmental and social effects;
- Proposed management measures; and
- Proposed rehabilitation and closure of the areas where mining would be undertaken.

Technical appendices to the PER are provided on CD with this document. The PER and technical appendices are also available on Toro's website (www.toroenergy.com.au). Hard copies of the PER can be ordered from Toro's Perth office on +61 (8) 9214 2100 or by email at info@toroenergy.com.au

2 ABOUT THE PROPOSAL

2.1 Introduction

The Proponent and the Proposal are introduced in this section with background on how the Extension to the Wiluna Uranium Project has developed to its current stage.

2.2 The Proponent and its Proposal

Toro Energy Limited is the Proponent of the Extension to the Wiluna Uranium Project.

Toro (ABN 48 117 127 590) is an Australian uranium company with a highly prospective project development and exploration portfolio. Toro was listed on the Australian Securities Exchange in March 2006. Toro's vision is to be a leading mid-tier global uranium company through responsible exploration, mining and asset growth. The development of uranium mining in the Wiluna region is Toro's main undertaking.

Toro has exploration interests in Western Australia, the Northern Territory and Namibia, Africa, and investments in uranium exploration and development stage companies in Canada.

The subject of this PER is Toro's proposed Extension to the Wiluna Uranium Project which involves the mining of two deposits, **Millipede** and **Lake Maitland**, as well as construction of an ore haul road and associated infrastructure. The regional location of the Proposal is shown in Figure 2.1 and Figure 2.2. Toro is the proponent on behalf of its 100% owned and controlled entities, Nova Energy and Redport, owners of the Millipede tenements and Lake Maitland tenements respectively.

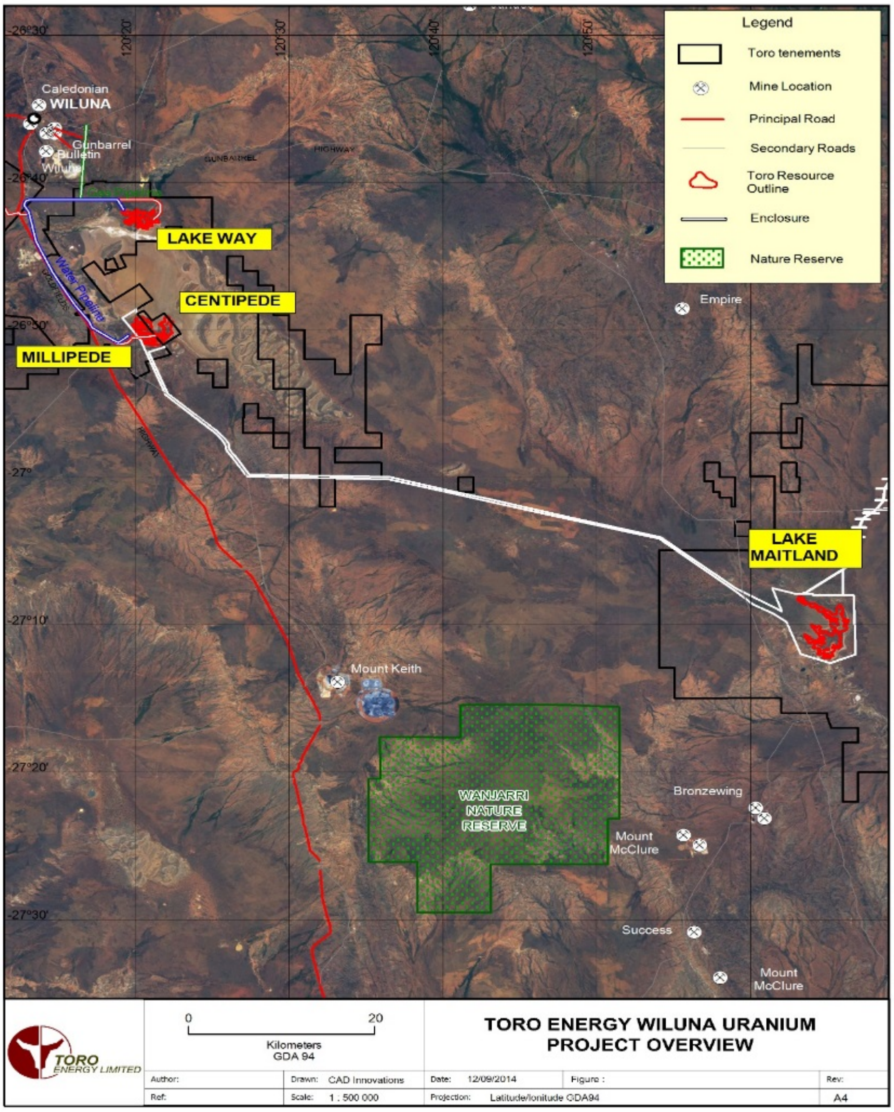
Figure 2.1: The Wiluna Uranium Proect in Western Australia

The Wiluna Uranium Project was the subject of EPA Assessment 1819 (EPA Report 1437). Following that assessment, the Western Australian Minister for Environment gave Toro approval in October 2012 (Ministerial Statement No. 913) to construct and operate a uranium mine consisting of two deposits, **Centipede** and **Lake Way**, respectively located approximately 30 kilometres (km) south and 15 km south-east of Wiluna. The federal Minister for Sustainability, Environment, Water, Population and Communities also approved that proposal (EPBC 2009/5174) in April 2013. Toro has not yet commenced mining of the Centipede and Lake Way deposits.

After initiating assessment and approval of the Wiluna Uranium Project, Toro acquired two additional deposits: Millipede, also approximately 30 km south of Wiluna and immediately adjacent to Centipede, and Lake Maitland, 105 km south-east of Wiluna. The proposed Extension to the Wiluna Uranium Project would allow Toro to integrate the Centipede, Lake Way, Millipede and Lake Maitland deposits into the Project. The method of mining all four deposits, processing of the ore and transport of finished product would be identical.

Ore from Millipede and Lake Maitland would be processed at the same plant as ore from Centipede and Lake Way. The capacity of the processing plant already approved following EPA Assessment 1819 and EPBC 2009/5174 would not increase under this Proposal. Instead, the plant's operating life could extend beyond 15 years, the period during which sequential mining would be undertaken at Centipede and Millipede, then Lake Maitland and finally Lake Way. During this period, the operation would produce up to 1200 tonnes per annum (tpa) of uranium oxide concentrate (UOC)—the current production limit approved under EPA Assessment 1819 and EPBC 2009/5174. Construction and pre-mining are scheduled to begin at Centipede by late 2016 and at Millipede at the same time, subject to government approval, financing and market conditions.

Figure 2.2: Regional location of the Wiluna Uranium Project



Toro acquired the Lake Maitland mining and associated leases in November 2013. The previous owners had referred to the EPA a proposal to develop Lake Maitland as a stand-alone mine with a processing plant (EPA Assessment 1821). As Toro's plans for Lake Maitland are now limited to mining and haulage operations, Toro has withdrawn the previous proposal and initiated this assessment process.

Millipede, like Centipede, is near the centre-west margin of the Lake Way playa (Figure 2.2). It covers an area approximately 2.5 km long (north to south) and up to 1.5 km wide, totalling approximately 176 hectares (ha). The Millipede and Centipede deposits are extensions of the same contiguous geological deposit that has been split into two deposits by tenement boundaries over time. For the purpose of this PER, the Millipede deposit refers to all ore contained within mining leases M53/1095 and M53/336. Within these two leases, three pits would be excavated, each about 2 km long with a maximum depth of 15 metres (m).

Lake Maitland is in close proximity to existing infrastructure including roads and an airstrip (Figure 2.2). The mineralisation is approximately 6 km long (north to south) and 2 km wide, totalling approximately 577 ha in area.

The principal components of this Proposal include:

- Establishment and operation of uranium mining at Millipede and Lake Maitland;
- Development of infrastructure (road, power, water source and supply facilities, access and haul roads, waste management facilities, including for tailings);
- Haulage of ore from Lake Maitland to the approved processing facility;
- Transport of finished product to either Adelaide or Darwin for shipment to overseas customers; and
- Closure and rehabilitation of mined and other disturbed areas.

This Proposal does NOT include:

- Any change to the composition or volume of tailings to be stored under already assessed (EPA Assessment 1819 and EPBC 2009/5174) arrangements in mined-out voids at the Centipede deposit. It remains Toro's intention as detailed during that assessment to store tailings from ore mined at Centipede and Lake Way in mined-out voids at Centipede. The composition and volume of those tailings as assessed is also unchanged;
- Any change to the already assessed (EPA Assessment 1819 and EPBC 2009/5174) annual maximum production capacity for the processing plant;
- Any change to the configuration of the processing plant; or
- Any additional drawdown of groundwater at West Creek beyond the level already assessed (EPA Assessment 1819 and EPBC 2009/5174) for mining and processing of the Centipede and Lake Way deposits. Dewatering at Millipede would comply with the approved drawdown as determined in Assessment 1819 and EPBC 2009/5174. The implementation of groundwater barriers would ensure that flows were restricted and dewatering limited to that already approved.

Toro referred this Proposal to the EPA on 20 February 2014. The EPA determined that the Proposal required assessment as a PER. This level of assessment was advertised by the EPA on 7 April 2014.

The PER must give a detailed assessment of each of the preliminary key environmental factors identified by the EPA for this Proposal.

Toro submitted a referral to the DoE on 20 February 2014. The DoE determined that the Proposal is a controlled action under the *Environment Protection and Biodiversity Conservation Act 1999* and will be assessed under a bilateral agreement between the Western Australian and federal governments.

A PER level of assessment requires preparation of an Environmental Scoping Document (ESD) setting out the environmental factors raised by the Proposal and the studies the Proponent has undertaken or proposes to undertake. Toro released its ESD on 6 October 2014 for two weeks of public consultation and presented the revised ESD to the EPA in November 2014. The ESD was approved by the EPA on 13 February 2015. The final ESD is available on Toro's website (www.toroenergy.com.au) and is Appendix A of this PER.

The key contact for this Proposal is:

Mr Andrew Worland, General Manager, Toro Energy Limited
Level 3, 33 Richardson Street
WEST PERTH, WA 6005
Phone: +61 8 9214 2100
Fax: + 61 8 9226 2958
Email: andrew.worland@toroenergy.com.au

Toro's head office and Wiluna Project team are based in Perth, Western Australia at the above address.

Toro's Website is: www.toroenergy.com.au

Toro's Project team and consultants represent over 200 years of collective experience in uranium exploration, project development, mining and processing operations. This includes involvement at a senior level at currently operating uranium mines in South Australia and the Northern Territory. Toro has also obtained independent technical reviews of the key studies undertaken to support this environmental assessment.

As part of its due diligence process, Toro has drawn on individuals with extensive experience and technical expertise in uranium and calcrete-style uranium mineralisation. This includes engineering, mining, processing, chemical, geological, and environmental and radiation professionals.

Toro's listing on the Australian Securities Exchange on 24 March 2006 was initiated to realize the uranium value in multi-mineral exploration tenements held by the then Oxiana Minerals (now Oz Minerals) and Minotaur Exploration. In August 2007, Toro and Nova Energy announced their intention to merge through a friendly takeover of Nova by Toro and, as a result, Toro gained ownership of the Centipede and Lake Way deposits. In 2009, Toro initiated the process to secure environmental approval to mine those two deposits and it was finalised in 2013.

In September 2011, Toro completed the acquisition of three tenements covering a uranium mineralised zone called Millipede, immediately adjacent to the Centipede deposit. Uranium mineralisation in this area had been originally identified during drilling in the 1980s. Toro acquired the tenements from MPI Nickel Pty Ltd, a subsidiary of Norilsk Nickel Australia Pty Ltd.

In August 2013, Toro signed a binding Term Sheet to acquire the Lake Maitland Uranium Project from Toronto Stock Exchange listed Mega Uranium Limited (Mega) in return for 415 million ordinary shares in Toro. The acquisition was completed in November 2013 and, as a consequence, Mega became a significant shareholder of Toro.

The Lake Maitland deposit was first identified during a regional aeromagnetic survey in 1967. Between discovery and the early 1980s, five companies were active in evaluating mining at Lake Maitland. After further exploration in 2005 by Redport Limited, that company was taken over by Mega in December 2006.

Mega is a Canadian mineral resources company with a focus on uranium projects in Canada, Cameroon and Australia. In 2009, Mega and Redport entered into an arrangement with JAURD International Lake Maitland Project Pty Ltd (JAURD) and Itochu Minerals and Energy of Australia Pty Ltd (IMEA) that granted JAURD and IMEA an option to acquire a 35% interest in Lake Maitland. Also in 2009, Mega initiated the assessment process to secure government environmental approvals for mining at Lake Maitland. After its acquisition of the project, Toro withdrew Mega's application because of proposed changes to the project configuration and has substituted this Proposal for further assessment of mining at Lake Maitland.

The acquisition of Millipede and Lake Maitland has provided Toro with a significantly larger combined uranium resource base in the Wiluna region. Toro's Joint Ore Reserves Committee (JORC) categorised total Mineral Resource base is now 76.5 million pounds of uranium (U_3O_8). This takes in the Millipede, Lake Maitland, Centipede and Lake Way deposits, as well as two others, Dawson Hinkler and Nowthanna. Only mining at Millipede and Lake Maitland is the subject of this Proposal; Centipede and Lake Way have previously received government environmental approvals and Dawson Hinkler and Nowthanna are to be the subject of further resource evaluation. When Toro originally acquired its interest in Centipede and Lake Way in 2007, its regional resource base was just over 19 million pounds of U_3O_8. Acquisitions and upgrades as a result of drilling at each of Centipede, Millipede, Lake Way, Lake Maitland, Dawson Hinkler and Nowthanna have contributed to the increased combined uranium resource base in the Wiluna region. Millipede and Lake Maitland together represent a JORC resource of 31.2 million pounds of U_3O_8. The total JORC resource for Centipede, Lake Way, Millipede and Lake Maitland is 56.5 million pounds of U_3O_8.

2.3 Proposal Location and Land Tenure

The Proposal is for shallow strip mining and associated infrastructure to be developed near the town of Wiluna, (Shire of Wiluna population ~1159), 960 km north-east of Perth and 600 km from the nearest coast. The area is in a semi-arid zone characterised by hot, dry summers and mild, dry winters (mean annual rainfall 255 millimetres (mm); annual evaporation approximately 3400 mm). The Wiluna region has an extensive history of mining activity and associated land disturbance since the discovery of gold in the region in 1896. There is one currently operating mine within 50 km of the Wiluna Township. The regional landscape is characterised by salt pans or playa lakes which result from the high evaporation rate and hot temperatures.

The Millipede deposit is approximately 525 km north of Kalgoorlie on the Lake Way Pastoral Station (lease L3114/1164 held by Toro), approximately 30 km south-east of Wiluna and 125 km north-west of Leinster. The deposit is close to the sealed Goldfields Highway between Kalgoorlie and Wiluna and to existing water, electricity and gas supply infrastructure, and other mining operations. The current dominant land use is pastoral. Mining and mine infrastructure for this Proposal would be located within Mining Leases M53/1095 and M53/336. The land is also used by Traditional Owners for traditional law and other customary land uses including, but not limited to, hunting and camping. In July 2013, the Federal Court of Australia granted Native Title in the land to the Wiluna People. Toro is negotiating a mining agreement with the Native Title Holders.

The Lake Maitland deposit is located approximately 435 km north of Kalgoorlie on the Barwidgee Pastoral Station (L3114/772 held by Toro), 105 km south-east of Wiluna and 90 km north-east of Leinster. It is close to existing infrastructure at the Bronzewing gold mine site, including roads and an airstrip. Access to the deposit from the west is via well-maintained shire roads and the unsealed Bronzewing Mine private road. Access from the north is via the Barwidgee to Wonganoo pastoral station road. Toro would construct an all-weather access road to the Lake Maitland deposit to connect with gazetted roads and a haul road to truck ore from Lake Maitland to the approved processing plant at Centipede. There are no public roads intersecting the proposed haul road. Mining and mine infrastructure (apart from the ore haul road) would be located within Mining Lease M53/1089 which lies on Barwidgee Pastoral Station. It is expected that the corridor for the haul road between Lake Maitland and the processing plant at Centipede can be established entirely within the Barwidgee and Lake Way pastoral leases. The current dominant land use is pastoral. There is no Native Title claim over the land.

3 LEGISLATIVE FRAMEWORK

This section explains the legislative framework for government assessment and approval of the proposed Extension to the Wiluna Uranium Project and regulation of the subsequent mining operation.

3.1 Key Legislative Requirements

The Proposal requires environmental approval from:

- The state Minister for Environment under the provisions of the *Environmental Protection Act 1986* (EP Act); and
- The federal Minister for the Environment under the provisions of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The EP Act and its associated regulations are the principal statute in Western Australia for environmental protection in the state. Part IV of the EP Act allows for referral, environmental assessment and implementation of proposals. Part V of the Act outlines the mechanisms for control of environmental impacts through a licensing system. The EP Act is administered by the Office of the Environmental Protection Authority (OEPA) and the Department of Environment Regulation (DER).

The EPBC Act is the legal framework to manage Matters of National Environmental Significance (MNES) including nuclear actions (such as uranium mining) and the protection of nationally and internationally important flora, fauna and ecological communities. The EPBC Act is administered by the federal DoE.

3.1.1 Western Australian Environmental Assessment Process

The environmental assessment process for the Extension to the Wiluna Uranium Project commenced with referral of the Proposal to the EPA. The referral document enabled the EPA to determine if the Proposal required assessment under Part IV of the EP Act and, if so, the level of assessment to be applied. Toro referred the Proposal to the EPA on 20 February 2014. On 7 April 2014, the EPA advertised the level of assessment as a PER with a 12 week public review period (CMS14025). In doing so, the EPA identified the following preliminary key environmental factors for the Proposal:

- Flora and Vegetation;
- Terrestrial Fauna;
- Terrestrial Environmental Quality;
- Subterranean Fauna;
- Inland Waters Environmental Quality and Hydrological Processes;
- Human Health;
- Heritage;
- Rehabilitation and Closure (subsequently amended by the EPA to Rehabilitation and Decommissioning); and
- Offsets.

A PER level of assessment requires the preparation of an ESD setting out the preliminary key environmental factors that should be considered during the environmental review and preparation of the PER, and identifying the studies necessary to enable the environmental impact of the Proposal to be assessed. On 30 September 2014, the ESD for the Proposal was approved for release by the EPA and made available for public review for a period of two weeks from 6 to 20 October 2014. Based on the 27 submissions received, Toro revised the ESD where necessary and submitted the revised ESD to the EPA in November 2014. The ESD was approved by the EPA on 13 February 2015. The final ESD remains available on Toro's website and is Appendix A of this PER.

Toro has prepared this PER in accordance with the scope documented in the approved ESD. Once the EPA was satisfied that the PER document addressed all of the preliminary key environmental factors and studies identified in the ESD, Toro was granted approval to release this PER for public review.

Public submissions on the PER received by the EPA will be provided to Toro. Toro is then required to prepare a summary of the issues raised and respond to them to the satisfaction of the EPA. The EPA will assess the PER document, submissions received and Toro's response to submissions, and obtain advice from any other persons it considers appropriate before submitting its report and recommendations to the state Minister for Environment. Any person may lodge an appeal with the Minister against the contents and/or recommendations of the EPA's report. The Minister will then provide a decision on whether the Proposal may be implemented and if so, the conditions attached to its implementation.

At this stage, the authorities listed in Table 3.1 have been identified as Decision Making Authorities for this Proposal. Additional Decision Making Authorities may be identified during the course of the assessment.

Table 3.1: Decision making authorities

Decision Making Authority	Relevant Legislation
Department of Mines and Petroleum	*Mining Act 1978*; *Mines Safety and Inspection Act 1994*; *Dangerous Goods Safety Act 2004*
Department of Environment Regulation	*Environment Protection Act 1986*
Minister for Water	*Rights in Water Irrigation Act 1914*
Radiological Council of Western Australia	*Radiation Safety Act 1975*
Minister for Aboriginal Affairs	*Aboriginal Heritage Act 1972*
Main Roads Western Australia	*Main Roads Act 1930*
Minister for Environment	*Wildlife Conservation Act 1950*
Shire of Wiluna	Development Approval

3.1.2 Federal Environmental Assessment Process

The EPBC Act provides for the protection of MNES. The Act lists eight MNES:

- World Heritage properties;
- National Heritage places;
- Wetlands of International Importance (listed under the Ramsar Convention);
- Listed threatened species and ecological communities;
- Migratory species protected under international agreements;
- Commonwealth marine areas;
- The Great Barrier Reef Marine Park; and
- Nuclear actions (including uranium mining).

The federal Minister for the Environment may assess a proposal using one of the following methods:

- Accredited assessment;
- Assessment on referral information;
- Assessment on preliminary documentation (referral form plus any other relevant material identified by the Minister);
- Assessment by Environmental Impact Statement (equivalent to a PER); or

- Assessment by Public Inquiry.

Toro referred the Proposal to the DoE on 20 February 2014 (EPBC Act Reference No. EPBC 2014/7138). On 25 March 2014, the DoE determined that the Proposal is a controlled action, because it may have a significant impact on the following MNES protected by the EPBC Act:

- Listed threatened species and communities; and
- Nuclear actions.

A Bilateral Agreement exists between the Australian Government and the Government of Western Australian which accredits the WA environmental assessment process, allowing for an integrated and coordinated approach to environmental assessment for actions requiring approval under both the EPBC Act and the EP Act. This means that a proposal can be assessed concurrently by the state EPA and the federal DoE using the same documentation prepared to meet the requirements of both Acts with the assessment coordinated by the EPA.

At the conclusion of the assessment, the federal Minister for the Environment will make a separate decision on the Proposal to the state Minister for Environment.

This PER has been prepared to meet both state and federal requirements.

3.1.3 Other Approvals

In addition to the environmental approvals required under Part IV of the EP Act and the EPBC Act, Toro will be required to obtain other approvals identified in Table 3.2 before being able to implement the Extension to the Wiluna Uranium Project including:

Table 3.2: Summary of other approvals required for development and operation of the Proposal

Agency/Authority	Approval Required
Commonwealth Department of Industry and Science (DoIS)	Approval to export product under Regulation 9 of *Customs (Prohibited Exports) Regulations 1956* under the *Customs Act 1901* (Cwlth).
Australian Safeguards and Non-Proliferation Office (ASNO) (Cwlth)	Permit to establish a uranium mining facility; Permit to possess and transport nuclear material – both under the *Nuclear Non-Proliferation (Safeguards) Act 1987*.
Western Australian Department of Mines and Petroleum (DMP)	Mining Proposal (including Mine Closure and Rehabilitation Plan), project management plan, tailings operating strategy (*Mining Act 1978*), radiation management plan (*Mines Safety and Inspection Act 1994*), dangerous goods licence (*Dangerous Goods Safety Act 2004*).
Western Australian Department of Environment Regulation (DER)	Works approval and licence under Part V of *Environmental Protection Act 1986*; permits to take may be required under the *Wildlife Conservation Act 1950*.
Western Australian Department of Water (DoW)	Licence to abstract water under *Rights in Water and Irrigation Act 1914*.
Radiological Council of Western Australia	Approval of radiation management plans, radioactive waste management plans and mine closure plans; licensing/registration of persons and premises under the *Radiation Safety Act 1975*; approval for storing, packing and transport of radioactive materials under the *Radiation Safety (Transport of Radioactive Substances) Regulations 2002* (including approval of a Radiation Protection Program for transport of radioactive substances).
Western Australian Department of Aboriginal Affairs (DAA)	Consent to disturb Aboriginal heritage sites under Section 18 of the *Aboriginal Heritage Act 1972* (if required).

Agency/Authority	Approval Required
Main Roads Western Australia (MRWA)	Construction and maintenance of roads pursuant to the *Main Roads Act 1930*.
Western Australian Department of Health; Shire of Wiluna	Sewage treatment permit pursuant to the *Health Act 1911 and Health (Treatment of Sewage and Disposal of Effluent and Liquid Waste) Regulations 1974*.
National Native Title Tribunal	Agreement for land access under the *Native Title Act 1993* (Cwlth) and the *Native Title (State Provisions) Act 1999*.
Shire of Wiluna	Building applications and other consents under the *Planning and Development Act 2005* and *Health Act 1911*.

The following is an explanation of the major additional approvals required to construct and operate the Extension to the Wiluna Uranium Project.

3.1.4 State Legislation and Regulations

Environmental Protection Act 1986

Under Part V of the EP Act, Toro will be required to obtain a number of Works Approvals prior to construction and Licences to Operate prior to commencement of mining. Supporting documentation for these approvals, including a detailed Project description, assessment of potential impacts and proposed management measures, will be submitted to the DER for assessment.

Mining Act 1978

Land tenure for mining projects is administered under the Mining Act by the DMP. Mining cannot commence unless the required tenure has been granted under the Mining Act or other applicable legislation. Toro is seeking appropriate tenure under the provisions of the Mining Act and the *Native Title Act 1993* (Cwlth).

Toro will need to submit a Mining Proposal to the DMP for approval under the Mining Act, prior to commencement of construction. The Mining Proposal will provide further details of the Proposal, including design of pits and waste rock and tailings storage facilities, and an assessment of potential impacts and proposed management. The Mining Proposal will also include a Mine Closure and Rehabilitation Plan requiring DMP approval before construction and operation can commence.

Rights in Water and Irrigation Act 1914

Toro will be abstracting groundwater during pit dewatering to allow mining to be undertaken safely and also for operational water supply. Toro will seek the necessary groundwater licences and permits to construct wells under this Act which is administered by the DoW.

Aboriginal Heritage Act 1972

The Aboriginal Heritage Act provides automatic protection for all places and objects in Western Australia that are culturally significant to Aboriginal people. There are a number of registered Aboriginal heritage sites in the vicinity of where mining and associated development would occur at Millipede. There are no registered sites in the vicinity of mining at Lake Maitland. Toro has prepared a Cultural Heritage Management Plan to provide protection for sites.

Where practicable, Toro would avoid disturbance to Aboriginal heritage sites and the values associated with those sites. If it is not possible to avoid such disturbance, Toro would consult with the Wiluna People as the Native Title Holders for the Millipede tenements, and the Barwidgee

People and others who claim an interest at Lake Maitland. Toro would then undertake any further heritage survey work required and, if necessary, apply for clearance from the Minister for Aboriginal Affairs under Section 18 of the Aboriginal Heritage Act to disturb land on which an Aboriginal site exists.

Radiation Safety Act 1975

Toro will be required to prepare a Radiation Management Plan for construction and operation of the Proposal for approval by the DMP and the Radiological Council. So far, evaluation of the Millipede and Lake Maitland deposits by Toro through resource definition drilling has been undertaken under an approved Exploration Radiation Management Plan.

The Proposal will also require a Radioactive Waste Management Plan and a Transport Management Plan to be approved by the Radiological Council, as well as the Mine Closure and Rehabilitation Plan.

Under the Radiation Safety Act, Toro will have to nominate a Radiation Safety Officer to hold the licence for mining and milling of radioactive ores. The owner of any premises in which any radioactive substance is manufactured, used or stored also requires registration under the Radiation Safety Act.

Regulatory requirements in relation to radiation management and protection also include:

- A licence for any premises in which a radioactive substance is manufactured, used or stored;
- A licence to transport radioactive substances; and
- An approved radiation protection program for transport of radioactive substances.

Toro will be permitted to seek the approvals listed in Table 3.2 on completion of the PER assessment process.

3.1.5 Commonwealth Legislation

Commonwealth laws applicable to the Proposal in addition to those listed in Table 3.2 include:

- *Aboriginal and Torres Strait Islander Act 2005*;
- *Aboriginal and Torres Strait Islander Heritage Protection Act 1984*; and
- *National Environmental Protection Measures Implementation Act 1998*.

3.2 International Agreements

Table 3.3 lists the applicable international agreements that the Australian Government is required to consider in its assessment of the Proposal.

Table 3.3: International agreements relevant to the Proposal

Agreement	Purpose
Treaty on the Non-Proliferation of Nuclear Weapons 1968 (NPT)	The NPT's objective is to prevent the spread of nuclear weapons and weapons technology, to promote cooperation in the peaceful uses of nuclear energy and to further the goal of achieving nuclear disarmament and general and complete disarmament. The Treaty entered into force in 1970 and 190 parties have joined the Treaty. More countries have ratified the NPT than any other arms limitation and disarmament agreement.
Australian Bilateral Nuclear Safeguards Agreements	Australia's long established policy is only to export uranium for peaceful purposes to countries and parties with which Australia has a bilateral safeguards agreement. Australia currently has 22 bilateral nuclear cooperation agreements in force covering 39 countries.

Agreement	Purpose
International Convention on Biological Diversity 1992	The objectives of this Convention are: • The conservation of biological diversity; • The sustainable use of its components; and • The fair and equitable sharing of the benefits arising out of the utilisation of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and technologies, and by appropriate funding.
Japan Australia Migratory Birds Agreement (JAMBA) 1974	This agreement between the governments of Australia and Japan for the protection of migratory birds and birds in danger of extinction and their environment seeks to protect and conserve habitats, and provides for information exchange and building cooperative relationships.
China Australia Migratory Birds Agreement (CAMBA) 1986	This agreement between the governments of Australia and the People's Republic of China has the same purposes and aims as the JAMBA.
Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA) 2006	This agreement between the governments of Australia and The Republic of Korea has the same purposes and aims as the JAMBA and CAMBA.

3.3 Policies, Guidelines and Standards

Planning of the Extension to the Wiluna Uranium Project and the studies carried out for the assessment of the possible impacts of the Proposal have had regard to recommendations contained in the following guidelines, policies and standards:

3.3.1 Western Australian Policies

- Environmental Protection Authority (EPA), 2009. *Draft State Environmental (Ambient Air) Policy* (since withdrawn).
- Department of Water (DoW), 2000. *State-wide Policy No. 5 – Environmental Water Provisions for Western Australia*.
- DoW, 2009. *Operational Policy No. 1.02; Policy on water conservation/efficiency plans*.
- DoW, 2009. *Operational Policy No. 5.12; Hydrogeological Reporting Associated with a Groundwater Licence*.
- DoW, 2011. *Operational Policy No 5.08; Use of operating strategies in the water licensing process*.
- Government of Western Australia, 2011. *WA Environmental Offsets Policy*.

3.3.2 Western Australian Position Statements

- EPA, 2000. *Environmental Protection of Native Vegetation Position Statement No. 2*.
- EPA, 2002. *Terrestrial Biological Surveys as an Element of Biodiversity Protection Position Statement No. 3*.
- EPA, 2004. *Environmental Protection of Wetlands Position Statement No. 4*.

3.3.3 Western Australian Guidance Statements

- Department of Aboriginal Affairs and Department of Premier and Cabinet, 2013. *Aboriginal Heritage Due Diligence Guidelines*, Version 3.0, 20 April 2013.
- EPA, 2006.*Rehabilitation of Terrestrial Ecosystems*, No. 6.

- EPA, 2002. *Guidance Statement for Minimising Greenhouse Gas Emissions*, No. 12.
- EPA, 2014. *Environmental Assessment Guideline for Consideration of environmental impacts from noise*, EAG 13.
- EPA, 2009. *Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment*, No. 20.
- EPA, 2009. *Environmental Guidance for Planning and Development*, Guidance Statement No. 33.
- EPA, 2004. *Assessment of Aboriginal Heritage*, No. 41.
- EPA, 2004. *Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia*, No. 51.
- EPA, 2007. *Sampling Methods and Survey Considerations for Subterranean Fauna in Western Australia*, No. 54a.
- EPA, 2004. *Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia*, No. 56.
- EPA, 2013. *Environmental Assessment Guideline for Environmental factors and objectives,* EAG 8.
- EPA, 2013. *Environmental Assessment Guideline for Consideration of subterranean fauna in environmental impact assessment in Western Australia*, EAG 12.
- EPA, 2014. *Environmental Protection Bulletin No. 1, Environmental Offsets*.
- Hyder BM, Dell J and Cowan MA, eds., 2010. Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Assessment. EPA and Department of Environment and Conservation (DEC).
- Department of Water (DoW), 2000. *Water Quality Protection Guidelines No. 10, Mining and Mineral Processing, Above-ground Fuel and Chemical Storage*.
- DEC, 2009. *Landfill Waste Classification and Waste Definitions 1996*, as amended.
- DER, 2004. *Bioremediation of Hydrocarbon Contaminated Soils in Western Australia*. Replaced by DER, 2014. *Assessment and management of contaminated sites, Contaminated sites guidelines*.
- Department of Minerals and Energy, 1999. *Guidelines on the Safe Design and Operating Standards for Tailings Storage*.
- Department of Mines and Petroleum (DMP), 2010. *Guideline Managing naturally occurring radioactive material (NORM) in mining and mineral processing*:

- *NORM–1 Applying the system of radiation protection to mining operations*
- *NORM–2.1 Preparation of a radiation management plan – exploration*
- *NORM–2.2 Preparation of a radiation management plan – mining and processing*
- *NORM–3.1 Monitoring NORM – pre-operational monitoring requirements*
- *NORM–3.2 Monitoring NORM – operational monitoring requirements*
- *NORM–3.3 Monitoring NORM – air monitoring strategies*
- *NORM–3.4 Monitoring NORM – airborne radioactivity sampling*
- *NORM–3.5 Monitoring NORM – measurement of particle size*
- *NORM–4.1 Controlling NORM – dust control strategies*
- *NORM–4.2 Controlling NORM – management of radioactive waste*
- *NORM–4.3 Controlling NORM – transport of NORM*
- *NORM–5 Dose assessment*
- *NORM–6 Reporting requirements*
- *NORM–7 BOSWELL – assessment and reporting database*

- DMP and EPA, 2015. *Guidelines for Preparing Mine Closure Plans*.
- DMP, 2013. *Code of Practice Tailings Storage Facilities in Western Australia*.
- Department of Health (DoH), 2007. *Health Impact Assessment in Western Australia Discussion Paper* and *Health Impact Assessment in Western Australia Summary Document*.

- DoH, 2006. *Health Risk Assessment in Western Australia*.
- DoH, 2004. *Environmental health risk assessment Guidelines for assessing human health risks from environmental hazards*.
- DoH, 2010. *Health risk assessment (scoping) guidelines*.
- Department of Premier and Cabinet, 2003. *Consulting Citizens – Planning for Success*.
- Water Authority of Western Australia, 1994. *Goldfields Groundwater and Management Plan*.
- Water and Rivers Commission, 2000. *Water Quality Protection Guidelines No. 1 – Water quality management in mining and mineral processing: An overview*.
- Water and Rivers Commission, 2003. *Mine void water resource issues in Western Australia*.
- DoW, 2011. *Groundwater risk-based allocation of planning process*, Water resource allocation and planning series Report No. 45.
- DoW, 2013. *Western Australian water in mining guideline*, Water licensing delivery series Report No. 12.
- Water Corporation of Western Australia, 2004. *Wiluna Water Reserve drinking water source protection assessment: Wiluna town water supply*.
- EPA, 2014. *WA Environmental Offsets Guidelines*.
- Chamber of Minerals and Energy of Western Australia, 2000. *Mine Closure Guideline for Mineral Operations in Western Australia*.

3.3.4 Western Australian Strategies

- DER, 2004. *Western Australian State Greenhouse Strategy – Western Australian Greenhouse Task Force*.
- Government of Western Australia, 2003. *Western Australian State Sustainability Strategy*.

3.3.5 National Policies, Guidelines and Strategies

- Australian Government and Australian Safeguards and Non-Proliferation Office. Nuclear Non-Proliferation Treaty and associated conventions, agreements and policies.
- Australian Government and state and territory governments, 1992. *Intergovernmental Agreement on the Environment*.
- Australian and New Zealand Environment Conservation Council (ANZECC) and the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ), 2000. *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*.
- Australia and New Zealand Minerals and Energy Council and Minerals Council of Australia, 2000. *Strategic Framework for Mine Closure*.
- Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), 2005. Radiation Protection Series 1–16: Code of Practice and Safety Guide for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing – specifically including RPS 1 (*Recommendations for limiting exposure to ionizing radiation* (1995) and *National Standard for limiting occupational exposure to ionizing radiation*); RPS 2 (*Safety Guide for the Safe Transport of Radioactive Material*); and RPS 9 (*Code of Practice and Safety Guide for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing*).
- ARPANSA, 2011. *Safety Guide for Monitoring, Assessing and Recording Occupational Radiation Doses in Mining and Mineral Processing*.
- ARPANSA, 2014. *Code for the Safe Transport of Radioactive Material*.
- ARPANSA, 2014. *A review of existing Australian Radionuclide Activity Concentration Data in Non-Human Biota inhabiting Uranium Mining Environments*. Technical Report 167.
- ARPANSA, 2010. *Environmental Protection: Development of an Australian approach for assessing effects of ionising radiation on non-human species*. Technical Report Series No. 154.

- Department of Industry, Tourism and Resources (DoITR), 2006. *Leading Practice Sustainable Development Programme for the Mining Industry – Mine Rehabilitation*.
- DoITR, 2007. *Leading Practice Sustainable Development Programme for the Mining Industry – Managing Acid and Metalliferous Drainage*.
- DoITR, 2008. *Leading Practice Sustainable Development Programme for the Mining Industry – Community Engagement and Development*.
- Department of Resources Energy and Tourism, 2008. *Leading Practice Sustainable Development Programme for the Mining Industry – Water Management*.
- Department of Industry and Resources, 1997. *Approved Procedure for Dose Assessment* Guideline RSG05.
- Department of Environment (DoE), various dates. Survey Guidelines and Recovery Plans for relevant species.
- DoE, various dates. *National Water Quality Management Strategy*.
- DoE, 1992. *National Strategy for Ecologically Sustainable Development*.
- DoE, 2001. *National Framework for the Management and Monitoring of Australia's Native Vegetation*.
- DoE, 2009. *National Biodiversity Strategy Review Task Group – Australia's Biodiversity Conservation Strategy 2010-2020, Consultation Draft*.
- DoE, 2009. *Matters of National Environmental Significance: Significant Impact Guidelines 1.1, Environment Protection and Biodiversity Conservation Act 1999*.
- Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC), 2011. Survey guidelines for relevant species.
- DSEWPaC, 2011. *EPBC Act Environmental Offsets Assessments Guide*.
- DSEWPaC, 2012. *EPBC Act Environmental Offsets Policy*.
- National Environment Protection Council (NEPC), 1999. *On-site containment of contaminated soil*.
- NEPC, 1999 (and related documents). *Assessment of site contamination NEPM*.
- NEPC, 2003. *Ambient Air Quality National Environmental Protection Measure (NEPM)*.
- NEPC, 2004. *Air Toxics NEPM*.
- NEPC, 2004. *Movement of Controlled Waste NEPM*.
- National Greenhouse Strategy (1998).
- National Greenhouse and Energy Reporting Strategy (2007).
- National Health and Medical Research Council, 2004. *Australian Drinking Water Guidelines*.
- National Occupational Health and Safety Commission, 2004. *Approved Criteria for Classifying Hazardous Substances [NOHSC:1008 (2004)] 3rd edition*.
- National Transport Commission, 2007. *Australian Code for the Transport of Dangerous Goods by Road and Rail* (7th Edition).
- National Waste Minimisation and Recycling Strategy.
- National Water Initiative.

3.3.6 International Policies and Guidelines

- International Atomic Energy Agency (IAEA), 2008. Security in the transport of radioactive material – IAEA Nuclear Security Series.
- IAEA, 2008. *Predisposal management of radioactive waste, general safety requirements Part 5*.
- IAEA, 2009. *Classification of radioactive waste, General safety guide no. GSG-1*.
- IAEA, 2009. *The management system for the safe transport of radioactive materials, Safety guide no. TS-G-1.4*.
- IAEA, 2009. *Regulations for the safe transport of radioactive material, 2009 Edition, Safety requirements no. TS-R-1*.

- IAEA, 2010. *Handbook of parameter values for the prediction of radionuclide transfer in terrestrial and freshwater environments, Technical report series No. 472.*
- IAEA International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources IAEA Safety Series No 115.
- IAEA Principles of Radioactive Waste Management Safety Fundamentals – IAEA Safety Series No. 111-F.
- IAEA, 2009. *Compliance assurance for the safe transport of radioactive material, Safety guide no. TS-G-1.5*.
- IAEA Extension of the Principles of Radiation Protection to Sources of Potential Exposure – IAEA Safety Series No. 104
- IAEA Evaluating the Reliability of Predictions Made using Environmental Transfer Models – IAEA Safety Series No. 100
- IAEA Radiation Monitoring in the Mining and Milling of Radioactive Ores (Jointly sponsored by IAEA, International Labour Organisation and World Health Organisation – IAEA Safety Series No. 95.
- IAEA The Application of the Principles for Limiting Releases of Radioactive effluents in the Case of the Mining and Milling of Radioactive Ores – IAEA Safety Series No. 90.
- IAEA Radiation Protection of Workers in the Mining and Milling of Radioactive Ores. 1983 Edition Code of Practice and Technical Addendum, Sponsored by IAEA, International Labour Organisation and World Health Organisation – IAEA Safety Series No. 26.
- International Council on Mining and Metals, 2008. *Planning for Integrated Closure: Toolkit.*
- International Commission on Radiological Protection (ICRP), 2008. *Environmental Protection - the concept and use of reference animals and plants*. Ann. ICRP 38 (4–6), 2008.
- ICRP, 2008. *Nuclear decay data for dosimetric calculations*. Ann. ICRP 38 (3), 2008.
- ICRP, 2007. *Scope of radiological protection control measures*. Ann. ICRP 37 (5), 2007.
- ICRP, 2007. *The 2007 recommendations of the International Commission on Radiological Protection*, Ann. ICRP 37(2-4), 2007.
- ICRP, 2006. *The optimisation of radiological protection - Broadening the process*, Ann. ICRP 36 (3), 2006.
- ICRP, 2006. *Human alimentary tract model for radiological protection*. Ann. ICRP 13 (1–2), 2006.
- ICRP, 2005. *Low-dose extrapolation of radiation-related cancer risk*. Ann. ICRP 35 (4), 2005.
- ICRP, 2003. *A framework for assessing the impact of ionising radiation on non-human species*. Ann. ICRP 33 (3), 2003.
- ICRP, 2002. *Basic anatomical and physiological data for use in radiological protection reference values*. Ann. ICRP 32 (3–4), 2002.
- ICRP, 1999. *Risk estimation for multifactorial diseases*. Ann. ICRP 29 (3–4), 1999.
- ICRP, 1999. *Protection of the public in situations of prolonged radiation exposure*. Ann. ICRP 29 (1–2), 1999.
- ICRP, 1997. *Individual monitoring for internal exposure of workers*. Ann. ICRP 27 (3–4), 1997.
- ICRP, 1997. *Radiological protection policy for the disposal of radioactive waste*. Ann. ICRP 27 (S), 1997.
- ICRP, 1997. *Protection from exposures - application to selected radiation sources*. Ann. ICRP (2), 1997.
- ICRP, 1997. *General principles for the radiation protection of workers*. Ann. ICRP 27 (1), 1997.
- ICRP, 1996. *Conversion coefficients for use in radiological protection against external radiation*. Ann. ICRP 26 (3–4), 1996.
- ICRP, 1995. *Age-dependent doses to members of the public from intake of radionuclides - Part 5 Compilation of ingestion and inhalation coefficients*. Ann. ICRP 26 (1), 1995.

- ICRP, 1995. *Age-dependent doses to members of the public from intake of radionuclides - Part 4 Inhalation dose coefficients*. Ann. ICRP 25 (3–4), 1995.
- ICRP, 1995. *Basic anatomical & physiological data for use in radiological protection – the skeleton*. Ann. ICRP 25 (2), 1995.
- ICRP, 1995. *Age-dependent doses to members of the public from intake of radionuclides - Part 3 Ingestion dose coefficients*. Ann. ICRP 25 (1), 1995.
- ICRP, 1993. *Age-dependent Doses to Members of the Public from Intake of Radionuclides: Part 2 Ingestion Dose Coefficients*. Ann. ICRP 23 (3–4), 1993.
- ICRP, 1994. *Human respiratory tract model for radiological protection*. Ann. ICRP 24 (1–3), 1994.
- ICRP, 1993. *Protection against radon-222 at home and at work*. Ann. ICRP 23 (2), 1993.
- ICRP, 1993. *Protection from potential exposure - a conceptual framework*. Ann. ICRP 23 (1), 1993.
- ICRP, 1991. *1990 Recommendations of the International Commission on Radiological Protection*. Ann. ICRP 21 (1–3), 1991.

4 COMMUNITY AND STAKEHOLDER CONSULTATION

This section describes the community and stakeholder consultation already undertaken by Toro and how Toro has responded to views and issues raised by the community and stakeholders. It also explains how Toro would undertake ongoing consultation during the government assessment, construction, operational, closure and rehabilitation phases of an Extension to the Wiluna Uranium Project, should the Proposal be approved.

4.1 Overview

Consultation by Toro in Wiluna and the wider region began immediately after the company acquired its interest in the Centipede and Lake Way tenements in 2007. The consultation is ongoing and has included discussion about proposed mining of the Millipede and Lake Maitland tenements since Toro acquired them.

In early 2009, the former owner of Lake Maitland (Mega) initiated regional community and stakeholder engagement and Toro has continued this engagement since acquiring the deposit in late 2013.

The consultation methods of Toro and Mega were broadly similar and the two companies had also collaborated with other uranium mining project proponents in local, regional and wider consultation on an industry basis.

Consultation to date has assisted Toro to identify issues and community concerns, thereby influencing design options and alternatives, as well as the development of community investment programs. Should the Proposal receive approval and proceed to development, ongoing consultation would focus on exchanging information and views about the construction, operational, closure and rehabilitation phases of the Proposal.

The studies and investigations undertaken for the Proposal have occurred over a number of years and the Proposal's configuration has been developed over this time to optimise its environmental performance, operational efficiency and economic return. As planning advanced, Toro and Mega continued a transparent community and stakeholder consultation program.

The level of consultation on each key issue identified in the ESD and the PER was determined according to the public interest and regulatory approach. In most cases, Toro has consulted to:

- Seek input and feedback on the Proposal;
- Keep affected communities and stakeholders informed; and
- Provide feedback on community and stakeholder concerns and how they have influenced design decisions.

Toro's consultation has included state, federal and local government agencies, Aboriginal people and organisations, the residents of Wiluna, Leonora, Laverton, Menzies and Kalgoorlie, non-government organisations, and people and organisations with wider interests. Toro has undertaken its own consultation specific to this Proposal in Wiluna and the wider region and also participated in industry initiatives to provide information about the Proposal and more general issues associated with uranium mining to local and regional communities. This has included participation in community forums in Kalgoorlie, Wiluna, Leonora, Laverton and Menzies.

Toro has consulted Traditional Owners and Native Title Holders through community meetings and their representative body, Central Desert Native Title Services (CDNTS). Toro is negotiating a mining agreement with the Wiluna Native Title Holders who were granted Native Title to their lands in July 2013 by the Federal Court. Those lands include the Millipede deposit and part of the southern ore haul road that connects the Lake Maitland deposit to the previously assessed processing facility at

Millipede/Centipede. Toro has also continued consultation with the Barwidgee and other Aboriginal people who claim an interest in Lake Maitland, the descendants of the Tjupan People. Lake Maitland is on the ancestral lands of the Tjupan.

4.2 Policy Statement

Toro's Board has endorsed the following Community Policy:

Community Policy

Toro Energy will operate the Wiluna Uranium Mine to ensure our host community benefits from its presence through:

- Working safely and sustainably
- Providing accurate and scientific information about uranium
- Protecting individuals, the community and the environment from any harmful radiological impacts
- Engaging openly and regularly and considering in particular the views of our host community in decision making
- Developing partnerships to support local economic and social aspirations through employment, training, financial and other means
- Respecting Aboriginal cultural heritage
- Monitoring and improving our environmental and social performance
- Complying with all applicable legislation and regulatory requirements.

During the PER assessment, continuing community and stakeholder consultation will:

- Provide a further means for communities and stakeholders to raise concerns and to provide suggestions and advice on the Proposal;
- Give further opportunities for communities and stakeholders to have input and feedback in order to further inform Toro's decision-making;
- Widen Toro's knowledge of the issues, concerns and opportunities that may arise in relation to the Proposal to enable the development of effective enhancement and mitigation strategies;
- Allow Toro to continue its interaction with communities and stakeholders and find the best ways to increase benefits from the Proposal and avoid or reduce adverse impacts; and
- Develop relationships to facilitate ongoing consultation over the life of the Proposal, including the management of mine closure issues.

4.3 Consultation Methods

The community and stakeholder consultation program was developed in accordance with relevant state and federal government guidelines for impact assessment. It also adopted best practice guidelines including the *Core Values for Public Participation* (IAP2, 2010) and the *Performance Standards and Guidelines on Impactive Stakeholder Engagement* (IFC, 2006).

The main steps in the initial consultation were to identify interested communities and stakeholders and to develop and implement a consultation program appropriate to the scale of the Proposal and its impacts and benefits.

In planning its consultation program, Toro defined a 'community' as one which may be directly affected by and/or benefit from the company's operations. 'Stakeholders' may not be directly affected by or benefit from Toro's operations, but may nevertheless have an interest in or influence over them.

Communities and stakeholders with an interest in the Extension to the Wiluna Uranium Project are identified in Table 4.1.

Table 4.1: Communities and stakeholders with an Interest in the Extension to the Wiluna Uranium Project

Category	Group/Individual
Government	• State and federal ministers and advisers • Members of state and federal parliaments (including respective shadow ministers) • State, territory and federal government departments and agencies (including for product transport, South Australia and the Northern Territory) • Local government representatives (Shires of Wiluna, Leonora, Laverton, Menzies; City of Kalgoorlie and councils along the product transport route in South Australia)
Non-government Organisations and Service Providers	• Community groups • Environmental groups • Private service providers
Industry and Business	• Local and regional industries and businesses • Regional economic development boards • Industry organisations
Aboriginal Groups	• Native Title Holders and Claimants • Other Aboriginal people claiming an interest in the Proposal
Landholders	• Pastoral lease holders and managers
General Public	• Local • Regional • State
Affected Communities	• Wiluna • Leonora • Menzies • Kalgoorlie

4.3.1 Government Consultation

Toro has met regularly with state and federal government ministers, shadow ministers and members of parliament, as well as departments and agencies involved in assessing the Proposal.

Representatives of state and federal regulatory agencies were contacted early in the consultation process to identify any issues or concerns they may have with the Proposal. The meetings focused on providing information about the Proposal and the methods to be adopted by Toro in addressing issues to inform the assessment process.

The agencies consulted during the preparation of this PER are given in Table 4.2.

Table 4.2: Agencies consulted

Region	Agency
Western Australia	Office of the Environmental Protection Authority Chairman of the Environmental Protection Authority Department of Mines and Petroleum Department of Environment Regulation Department of Parks and Wildlife Department of Water Department of Aboriginal Affairs Department of Premier and Cabinet Main Roads Western Australia Radiological Council of Western Australia
Federal	Department of the Environment Department of Industry and Science Australian Safeguards and Non-Proliferation Office
South Australia (Finished Product Transport)	Department of Premier and Cabinet Outback Communities Authority
Northern Territory (Finished Product Transport)	Department of Natural Resources, Environment, the Arts and Sport Northern Territory Worksafe Darwin Port Corporation
Local Government – Western Australia (including for Finished Product Transport)	Shire of Wiluna Shire of Leonora Shire of Menzies City of Kalgoorlie-Boulder Shire of Coolgardie Shire of Dundas
Local Government – South Australia (Finished Product Transport)	District Council of Ceduna District Council of Streaky Bay District Council of Wudinna District Council of Kimba Whyalla City Council Port Augusta City Council

4.3.2 Other Public Dissemination of Information

Toro has provided regular public updates on the progress of the Proposal, including in its quarterly, half-yearly and annual reports and public announcements. Table 4.3 lists the announcements made in relation to the proposed Extension to the Wiluna Uranium Project.

Table 4.3: Public announcements

Date	Announcement
17 February 2011	Acquisition of Millipede tenements from MPI Nickel Pty Ltd, a subsidiary of Norilsk Nickel Australia Pty Ltd.
23 September 2011	Execution of comprehensive legal documentation with MPI Nickel setting out commercial and legal framework for purchase of the Millipede tenements.
16 October 2011	A 32% increase in Wiluna regional resource, including 6.6 million pounds of contained U_3O_8 at Millipede.
12 August 2013	Toro enters binding terms sheet to acquire the Lake Maitland Uranium Project from Mega Uranium Ltd.
9 September 2013	High grade mineralisation identified following further drilling at Millipede.
4 October 2013	Approval by Foreign Investment Review Board for Lake Maitland acquisition.
18 October 2013	Overwhelming Toro shareholder support for Lake Maitland acquisition.
20 November 2013	Completion of Lake Maitland acquisition.
30 January 2014	Completion of independent mining scoping study and preliminary economic assessment for integration of Lake Maitland into the Wiluna Uranium Project.
24 February 2014	Initiation of government assessment and approval process for mining at Millipede and Lake Maitland.
16 April 2014	Toro commences 16,000 metres of drilling at Wiluna Uranium Project.
7 July 2014	Highest ever recorded grade of uranium mineralisation at Millipede.
2 September 2014	Positive Disequilibrium Results at Wiluna Uranium Project.
18 September 2014	Closed spaced drilling results at Wiluna exceed expectations.
6 October 2014	Public Release of ESD for mining at Millipede and Lake Maitland.
4 November 2014	Unitisation Agreement with Sentient Group to provide $10 million in project funding.
18 February 2015	EPA approval of Environmental Scoping Document.
25 May 2015	New resource drilling commences at Toro's Wiluna Uranium Project in WA.
June 11 2015	Toro halves debt in deal with major shareholder.
August 18 2015	Wiluna Uranium Project Technical Studies.
August 25 2015	Community consultation begins for extension for Wiluna Uranium Project
September 4 2015	Toro pushes ahead with Wiluna as Japan reactors re-start.
October 15 2015	20% increase in mineral resources at Centipede/Millipede.

Progress reports on the Wiluna Uranium Project, including its extension, were provided in presentations by Toro to the conferences shown in Table 4.4.

Table 4.4: Conferences

Date	Conference
15 May 2013	Friends of Mining and Resources – Canberra
5 June 2013	Australian Uranium Association Conference – Perth
28 June 2013	GVROC – Kalgoorlie
8 July 2013	AusIMM Perth Branch – Perth
29 August 2013	ANZ WA Natural Resources Team – Perth
15 October 2013	AMCHAM – Perth
24 October 2013	Western Australian Mining Club – Perth
13 February 2014	Austmine – Perth
10 March 2014	Aboriginal Women's meeting – Wiluna
10 April 2014	Western Australian School of Mine Graduates Association – Perth
16 May 2014	Austmine – Adelaide
28 May 2014	MCA Minerals Week – Canberra
23 June 2014	International Atomic Energy Agency conference – Vienna
16 July 2014	Australian Uranium Conference
12 August 2014	AusIMM New Leaders
16 October 2014	Brisbane Mining Club
23 October 2014	What's Down the Track Forum – Kalgoorlie
12 January 2015	Australian Business Week in India, Delhi and Mumbai
6 February 2015	Australia – China Bilateral Dialogue on Resource & Energy Cooperation, Perth
2 March 2015	PDAC, Toronto
5 March 2015	ASX Spotlight, New York
13 April 2015	SAREIC Conference, Adelaide
30 April 2015	International Mining for Development, Adelaide
5 May 2015	Sentient Annual General Meeting, Chicago
13 May 2015	AECOM
19 May 2015	Melbourne Mining Club, Melbourne
10 June 2015	ASX Series, Perth
11 June 2015	AUSIMM, Adelaide
1 October 2015	Sydney Mining Club

4.3.3 Outcomes of the Environmental Scoping Document

The Draft ESD for the Extension to the Wiluna Uranium Project was on public exhibition for a two week period from 6 October 2014. Its availability was advertised in the West Australian and Kalgoorlie Miner newspapers. Copies were also mailed by Toro to a range of community and stakeholder representatives and placed on the Toro website.

In addition to government departments, agencies, and federal and state members of parliament, Toro sent the ESD to the following:

- Shire of Wiluna;
- Shire of Leonora;
- Shire of Menzies;
- City of Kalgoorlie;
- Nganagganawili Aboriginal Health Service;
- Central Desert Native Title Services;
- The Barwidgee People;
- Kalgoorlie-Boulder Chamber of Commerce and Industry;
- Mid West Development Commission;
- Goldfields Esperance Development Commission;
- Chamber of Minerals and Energy;
- Wilderness Society of Western Australia;
- Conservation Council of Western Australia; and
- Australian Conservation Foundation.

There were 27 submissions on the ESD and Toro prepared a response to the EPA on all issues raised in the submissions. Table 4.5 summarises the submissions received and Toro's responses.

Many comments related to what information should be provided in the PER. Some of the issues raised in submissions were beyond the scope of the Proposal and the government assessment and approval process. Toro also notes that the main purpose of the ESD was to identify the preliminary key environmental factors or issues and the work that needed to be carried out for the environmental review to enable those factors and issues to be addressed fully in this PER.

Table 4.5: Summary of submissions and responses to the ESD

Issues Raised by Submitters	Toro Response	PER Response and Reference
Because mining at Centipede and Lake Way is now part of a larger proposal, mining at those locations should be re-assessed, including cumulative impacts, particularly in relation to water use and tailings management.	The method of assessment complies with all legal requirements. In the PER, Toro will address cumulative impacts of mining at Centipede, Millipede, Lake Maitland and Lake Way. This Proposal does not affect the mining of the Centipede and Lake Way deposits or the nature or design of the processing facility and operation philosophy already approved through EPA Assessment 1819 and EPBC 2009/5174.	Section 6 and Sections 9–18
The ESD is inadequate.	The ESD was prepared in accordance with EAG 10 *Environmental Assessment Guideline for Scoping a Proposal* (EPA, 2013).	Not applicable (N/A)

Issues Raised by Submitters	Toro Response	PER Response and Reference
Independent environmental reviews should be undertaken.	The environmental assessment of the Proposal is undertaken independently of Toro. A PER is the highest level of assessment, allows for extensive public consultation and ensures key environmental factors can be addressed appropriately.	N/A
Inadequacy of baseline studies.	The baseline studies have complied with EPA Guidance Statements and requirements. The outcomes of the baseline studies will be discussed extensively in the PER and baseline study reports will be provided as appendices to the PER.	Sections 9–18 and appendices
Opposition to uranium mining and the wider nuclear industry. Need for the global implications of exporting uranium from Wiluna to be examined.	Toro notes opposition to uranium mining and the nuclear industry. The impacts of the nuclear industry beyond uranium mining are outside the scope of the assessment. Concerns which are specific to this Proposal will be addressed in the PER.	Sections 9–18
No evidence that least-impact scenarios have been considered and that the proposed location of the processing plant is the best and safest available.	Incorporation of Lake Maitland into the Wiluna Project would reduce the regional footprint and environmental impacts by reducing duplication of operations and infrastructure. The PER will explain project design and other measures to avoid, minimise and mitigate impacts and discuss reasons for the location of the processing plant.	Section 5.2 and Sections 9–18
The adequacy of government regulation of uranium mining.	This is a matter for government. As a minimum, Toro will continue to comply with all government legislative and regulatory requirements.	Section 19
Concern that tailings remain radioactive for thousands of years and that catastrophic events could compromise their storage	The ESD requires Toro to explain in the PER how tailings management would ensure impacts are not greater than predicted. This will include demonstrating how the environment would be protected from events such as flooding.	Sections 13 and 16
Concern that this will be the first calcrete mine in Australia and Toro does not have the expertise to manage it.	Toro's Project Team and consultants represent well over 200 years of collective experience in uranium mine project development and operations. Toro has also commissioned advice from a company with extensive expertise and experience in uranium mining and alkaline leaching processes, including at Trekkopje, a calcrete-style deposit in Namibia.	N/A
Need for investigation of surface water flows/impacts during flooding of the Lake Way and Lake Maitland systems	Toro will discuss its surface water hydrological and flood studies in the PER.	Section 13
Concern that Toro has not identified a sustainable water supply to support its proposed operations.	In the PER Toro will provide a water balance for mining at Millipede, Lake Maitland, Centipede and Lake Way and demonstrate that it does have a sustainable water supply.	Section 6.6 and 13

Issues Raised by Submitters	Toro Response	PER Response and Reference
Concern about contamination of waterways, including from radioactive isotopes, tailings and radon gases.	Toro's investigations to characterise hydrogeological systems have included modelling of fate and transport of radioactive and non-radioactive contaminants and the outcomes will be discussed in the PER. The Mine Closure and Rehabilitation Plan will also address water monitoring and any mitigation measures required.	Section 16
Concern that the Wiluna town water supply may be affected by the Proposal.	Toro has undertaken a hydrogeological assessment to take into account impacts on other water users and the outcomes will be discussed in the PER. There is no hydraulic connection between Toro's mining areas and the town's water supply.	Section 13
Concern about the implications of climate change and extreme weather events on Toro's capacity to contain affected water in its mine site.	Toro's surface water, hydrological and flood studies will be discussed in the PER. Official weather and climate records do not show any pattern towards increasing rainfall in the region in the past three decades. Instead, they predict the climate at Wiluna will continue to dry.	Section 13
Concern that radioactive isotopes will bio-accumulate in the food chain.	Bush tucker assessments have been undertaken and the outcomes will be discussed in the PER.	Sections 9 and 14
Full mine closure plans should be made available to the public for comment.	Toro's Mine Closure and Rehabilitation Plan will be included in the PER and, therefore, will be publicly available for comment.	Section 16 and Mine Closure and Rehabilitation Plan
The costing of mine closure has not been disclosed, increasing the likelihood of taxpayers being left to foot a future clean-up bill.	Toro will comply with all legislative and regulatory requirements in relation to mine closure and rehabilitation, including funding of closure and rehabilitation.	Section 16 and Mine Closure and Rehabilitation Plan
A broader scope of consideration of the health of Aboriginal people beyond the limits of the Native Title negotiation process should be applied.	Toro has participated in regular meetings of Wiluna Traditional Owners. It has also consulted with Aboriginal people with an interest in mining at Lake Maitland. This system of representation is not for Toro to determine, but Aboriginal people themselves.	Sections 4 and 15
Radiation dose limits need to be reassessed in light of recent scientific research on the risks associated with radon progeny. Toro's representation of natural background levels of radiation in the Wiluna region has been inadequate and inaccurate and may be a danger to people.	Toro adheres to the recommendations of the ICRP and the IAEA which have been adopted in Australia through state and territory legislation or through stipulations of ARPANSA, including the assessment of natural background levels of radiation. Toro would implement systems to limit Project-related doses with a focus on ensuring they comply with the As Low As Reasonably Achievable principle. Internationally recommended radiation exposure limits have been stable. There has been only one reduction in the limits in the past 50 years.	Section 14

Issues Raised by Submitters	Toro Response	PER Response and Reference
Radioactive poisons particularly target the young and unborn, causing miscarriages and deformities, and child thyroid cancer and many other afflictions.	Toro notes the concern of the submitter. Its radiation management will seek to minimise radiation doses to people of all ages to avoid impacts on human health. Potential radiation exposures to the public as a result of implementing the Proposal will be discussed in the PER.	Section 14
Concern regarding alpha radiation being inhaled via dust in contaminated areas.	Toro will detail in the PER its dust suppression and control mechanisms designed to meet best practicable technology standards.	Section 14
The adequacy of Toro's public consultation, including with Aboriginal people.	Toro's consultation will be discussed in the PER, including outcomes and any adjustments to the Proposal as a result of this consultation and future plans for consultation.	Sections 4 and 19
Impacts on and access to culturally significant sites within the Project area should be assessed.	The PER will discuss extensive heritage survey work undertaken and also include a Cultural Heritage Management Plan establishing arrangements for protecting and managing Aboriginal Heritage, regular consultation and liaison with Traditional Owners about impacts during the construction and operational phases and maintaining land access which is compatible with mine safety.	Sections 4 and 15
An analysis of greenhouse gas emissions from the mining processes, milling and transportation was requested.	The Proposal would adopt natural gas as its primary fuel source. Overall, the Proposal is not predicted to result in significant emissions of greenhouse gases. Rather, it would provide opportunity for significant savings of emissions through replacement of greenhouse intensive fuels, such as coal.	Section 18
Toro should provide detailed risk assessments of transporting radioactive materials based on projections of increased traffic in the region.	The PER will include a Transport Management Plan providing for monitoring, emergency response and security procedures. The plan will include a discussion of current traffic flows in the region and any impact implementation of the Proposal would have on them.	Section 19
Concern that additional mining in the Wiluna region will significantly increase the distance radioactive material would be transported and increase the statistical chance of accidents.	Toro's risk assessment work has included product transport and the outcomes will be discussed in the PER. The proposed Extension to the Wiluna Uranium Project to include mining at Millipede and Lake Maitland would not increase the rate of product transport or change the method from that already assessed and approved.	Sections 14 and 19

4.3.4 Local Issues – Wiluna

Consultation has been undertaken in Wiluna through public meetings, meetings with Native Title Holders and Traditional Owners, and discussions with representatives of the shire and service providers, including health, education and police.

Aboriginal people in Wiluna have continued to indicate that their priorities are protection of their cultural heritage, assurances about radiation management and protection, avoidance of impacts on groundwater, flora and vegetation, and continuing accessibility to land for customary Aboriginal uses.

Concerns raised by the wider community have focused on potential impacts of population growth induced by construction and operation of the Proposal including:

- Increased local demand for medical and other services and access to infrastructure;
- Control of dust;
- Impacts on surface and groundwater;
- Management of occupational and public health issues;
- Drinking water quality;
- Emergency response management; and
- Interaction between the local community and any fly-in/fly-out workforce participants.

An issue regularly raised during local community consultation has been the location of the accommodation village with some differing views expressed. On the one hand, it has been suggested that establishing the accommodation village within or very close to the town could provide infrastructure which would remain available to the community for other uses at the end of the mine life. On the other hand, concerns have been expressed about social and cultural pressures that could arise from the influx of a large number of non-permanent residents. On balance, Toro believes it is in the community's best interest to accommodate the non-residential workforce at some distance from the Wiluna Township. At the same time, Toro will consider establishing some housing in Wiluna for operational management and how it may be able to work with the Shire of Wiluna to enhance local recreational and other infrastructure for mutual community and company benefits. These issues are further discussed in Section 19.

4.3.5 Consultation with Aboriginal People and Groups

Millipede

Based on its review of available heritage information, Toro initiated consultation in 2007 with Aboriginal people who may hold knowledge of Aboriginal cultural heritage values, including Native Title claimants, informants for recorded heritage sites and those identified by professional anthropologists as having relevant knowledge. This also included contact with CDNTS as the representative body for the Wiluna area pursuant to the *Native Title Act 1993*. CDNTS was incorporated in 2007 to provide a Native Title service in the region. CDNTS represented the Wiluna People in their award of Native Title by the Federal Court. The main determination was handed down by the court 'on country' near Wiluna on 29 July 2013. At the invitation of the Native Title Holders, Toro attended the ceremonial court sitting.

Toro has been undertaking heritage surveys with the Wiluna People since 2007 (Table 4.6). The information identified has added to the heritage record of the Wiluna area available from a large number of previous surveys undertaken since the 1970s. Toro's surveys have been undertaken by the Wiluna People with the assistance of anthropologists and archaeologists commissioned by CDNTS to assess areas in which Toro proposed to undertake ground disturbance.

Table 4.6: Summary of heritage surveys conducted with the Wiluna People

Item	Description
16 and 17 October 2007	
Purpose and Outcome	A Work Area Ethnographic Survey over the whole of tenement E53/1132 for further exploration activity. The survey resulted in a request from Traditional Owners that no ground disturbing activity be undertaken in certain areas. The request was complied with.
Number of Traditional Owner Informants	Six Traditional Owners surveyed the area by foot and four wheel drive vehicle
Date and Title of Survey Report (Consultant Anthropologist)	Heritage Survey Report – Work Area Survey – Tenement E53/1132 (Dr Bill Kruse)
1 and 2 November 2009	
Purpose and Outcome	A Work Program Ethnographic Survey for groundwater exploration on tenement L53/150; further exploration of the Centipede deposit (E53/1287; P53/1397; P53/1396; P53/1357; P53/1356; M53/113; P53/1355; P53/1372; M53/224); further exploration of Lake Way deposit (E53/1168; E53/1132; E53/1288; P53/1350; P53/1370; P53/1369; M53/121; M53/49; M53/45). The survey resulted in clearance for the establishment of eight new water bores and a resource evaluation pit, and some restrictions on drill locations on the Centipede and Lake Way deposits.
Number of Traditional Owner Informants	Seven Traditional Owners surveyed the areas by foot and four wheel drive vehicle
Date and Title of Survey Report (Consultant Anthropologist)	Heritage Survey Report – Work Program Survey for Toro Energy Ltd – L53/150 Water Licence, Centipede Deposit, Lake Way Deposit – November 2009 (David Raftery)
22 and 23 April 2010	
Purpose and Outcome	A Work Program Survey to clear areas for Core Farm facility on tenement M53/113; a meteorological station on M53/224; 20 soil test pits on P53/1355; P53/1356; P53/1357; P53/1396; E53/1132; M53/113; L53/150. The location for the Core Farm facility was cleared with a request that the proposed fence be sunk and meshing placed around the bottom; all materials containing uranium were securely stored; and access to the facility be strictly monitored to ensure no unauthorised access. All requests have been complied with. The location for the meteorological station was cleared with a request that all associated ground disturbing activity be confined to land previously disturbed and that the land be rehabilitated after use. The station was established on previously disturbed land which will be rehabilitated after use. The locations of the soil test pits were approved with the request that all new access tracks take the shortest possible route from established tracks, access to two locations be undertaken from the east and there be no vehicle access through a previously not cleared area at the Lake Way deposit. All requests were complied with.
Number of Traditional Owner Informants	Seven Traditional Owners surveyed the areas by foot and four wheel drive vehicle
Date and Title of Survey Report (Consultant Anthropologist)	Heritage Survey Report – Work Program Survey for Toro Energy Limited, P53/1355, P53/1356, P53/1357, P53/1396, E53/1132, M53/113, M53/224 and L53/150, conducted between the 22April and 23April 2010 – May 2010 (Jeremy Maling)

Item	Description
October 2011	
Purpose and Outcome	An ethnographic work area clearance survey of tenements at Millipede and Dawson Hinkler using a methodology aimed at considering maximum drilling activity across the whole area. The survey team identified a number of not-cleared areas which were advised to Toro. All other parts of the work area were cleared for maximum drilling activity.
Number of Traditional Owner Informants	Six Traditional Owners surveyed by foot and four wheel drive vehicle accompanied by an anthropologist and a CDNTS liaison officer.
Date and Title of Survey Report (Consultant Anthropologist)	Report of an Ethnographic work Area Clearance Survey for Toro Energy Ltd – Dawson Hinkler and Millipede Project Areas – Wiluna and Tarlpa Native Title Claims, Western Australia. By David Raftery, October 2011.
September 2012	
Purpose and Outcome	An archaeological survey using a work program clearance survey model of the Millipede and Dawson Hinkler tenements. All areas inspected were archaeologically cleared.
Number of Traditional Owner Informants	Six Traditional Owners surveyed by foot and four wheel drive vehicle accompanied by a CDNTS archaeologist.
Date and Title of Survey Report	Report of an Archaeological Work Program Clearance Survey within Toro Energy Ltd E53/1593 and M53/1092, Tarlpa Native Title Claim, Western Australia. Prepared for Central Desert Native Title Services Limited by Emlyn Collins – September 2012
December 2012	
Purpose and Outcome	An archaeological survey of proposed drilling locations on the Lake Way deposit and an ethnographic survey of areas of the Millipede tenements. All drilling locations at Lake Way were cleared. As a result of the survey at Millipede, an archaeological survey of one area was requested before the commencement of proposed drilling activities.
Number of Traditional Owner Informants	Eight Traditional Owners surveyed by foot and four wheel drive vehicle accompanied by an archaeologist and a senior anthropologist.
Date and Title of Survey Report	Report on an archaeological work program clearance survey at Toro Energy Limited's Lake Way Project Area and an Ethnographic Work Area Clearance Survey at Toro Energy Limited's Millipede Project Area, Wiluna and Tarlpa Native Title Claims, Western Australia. Prepared for Central Desert Native Title Services Limited by Emlyn Collins and Jeremy Mailing – December 2012.
March 2013	
Purpose and Outcome	An archaeological survey using a work program clearance survey model of areas in the northern section of the Millipede tenements. All proposed works were archaeologically cleared.
Number of Traditional Owner informants	Seven Traditional Owners surveyed by foot and four wheel drive vehicle accompanied by an archaeologist.
Date and Title of Survey Report	Millipede North – Report of an Archaeological Work Program Clearance Survey within Toro Energy Ltd M53/1095 – Tarlpa Native Title Claim, Western Australia. Prepared for Central Desert Native Title Services Limited by Emlyn Collins – March 2013.

In October 2010, ethnographic cultural mapping was undertaken by the Wiluna People with funds provided by Toro. The mapping covered a wide area including where the Millipede tenements are located. Following this cultural mapping, Toro has been provided with a map depicting the results of historic and contemporary ethnographic research, including specific locations of cultural significance to the Wiluna People. Toro has used this map to assist in its consideration of the Proposal.

In addition to heritage surveys and cultural mapping, Toro has undertaken site visits with representatives of the Wiluna Native Title Holders to discuss the configuration of the Proposal, including mining at Millipede and the establishment of a haul road from Lake Maitland to the processing plant.

Toro has also provided progress reports on the Extension to the Wiluna Uranium Project at the meetings shown in Table 4.7.

Table 4.7: Consultation with Traditional Owners

Date	Event
23 May 2012	Meeting with Wiluna People in Wiluna to provide progress report on Proposal.
29–31 October 2012	Meetings with the Wiluna People in Wiluna to discuss the commencement of mining agreement negotiations—during these discussions Toro provided a progress report on the Proposal.
9 April 2013	Meeting with the Wiluna People in Wiluna—progress report on Proposal provided—Toro also funded the participation of an independent adviser on radiation selected by the Traditional Owners.
16 May 2013	Visit of 16 Wiluna People to the Millipede tenements to discuss exploration and mining activities.
9–10 September 2013	Meeting with Martu Rangers in Wiluna to discuss capacity building in radiation monitoring through training funded by Toro.
17–18 December 2013	Mining agreement negotiation meeting in Perth attended by eight members of the Wiluna People's negotiating team.
10 March 2014	Meeting in Wiluna with Aboriginal women. Toro provided a progress report on the Proposal and a site visit.
28-29 July 2014	Mining agreement negotiation meeting in Wiluna attended by eight members of the Wiluna People's negotiating team.
17–18 September 2014	Toro participation in Careers Expo in Wiluna organised under the auspices of the Wiluna Regional Partnership Agreement—during the Expo Toro provided information about the Proposal to Aboriginal people living in Wiluna and Leonora.
12 August 2015	Meeting with the Wiluna People to discuss current status of project and progress of mining agreement negotiation following change in their legal representation.
12-15 October 2015	Survey of haul road alignment; visit to Millipede to review heritage issues; workshop to finalise Cultural Heritage Management Plan; mining agreement negotiation meeting in Wiluna.

Arising from its continuing consultation with the Wiluna People, Toro so far has:

- Provided funding through CDNTS for independent experts to give advice to the Wiluna People about radiation, groundwater management and the commercial terms of a mining agreement;

- Entered into a Memorandum of Understanding with CDNTS for the Wiluna People to undertake training and development in radiation monitoring and protection with a view to such services being provided to Toro by the Wiluna People on a commercial basis;
- Commissioned the Wiluna People to undertake drill hole rehabilitation work;
- Continued to discuss the configuration of the Proposal to accommodate cultural heritage issues. In particular, Toro would continue to avoid, in its tailings management at Millipede, any above ground structure for tailings storage; the in-pit disposal method already approved for tailings storage at Centipede (EPA Assessment 1819 and EPBC 2009/5174) would be mirrored at Millipede;
- Reviewed its plan for water consumption from West Creek in response to concerns about potential impacts on vegetation;
- Discussed arrangements for continuing consultation through the life of mining and closure to ensure the Wiluna People remain fully informed at all times about impacts and the outcomes of environmental monitoring; this would include a Liaison Committee comprising Wiluna People and Toro representatives to meet on a quarterly basis following the commencement of construction;
- From the commencement of the construction phase, committed to the appointment of a dedicated Aboriginal Liaison and Development Officer to be responsible on a day-to-day basis for managing the company's engagement with Aboriginal people; and
- Agreed to fund the Wiluna People to be able to manage their liaison with the company.

Lake Maitland

There is currently no Native Title claim registered over the area covered by the Proposal.

Mega established a positive working relationship with a Traditional Owner group proposing to lodge a native title claim over the area to be mined and provided assistance to begin the necessary work to support the lodgement of a claim.

The group had been nominated as potential claimants for the area through a process initially supported by CDNTS. Subsequently, some members of the group, the Barwidgee People, decided to seek independent legal representation and Mega continued to engage with them through regular meetings in Perth, Kalgoorlie and on site.

Mega established an Indigenous Steering Committee chaired by Mr Warren Mundine, currently head of the Prime Minister's Indigenous Advisory Council. During 2009–10, the steering committee provided information to the Barwidgee People about proposed mining at Lake Maitland and considered issues including cultural heritage protection, and employment and business development opportunities.

In 2009, Mega sought further information about Aboriginal interests at Lake Maitland. This resulted in an anthropological report (de Gand, 2009) which recommended further ethnographic and archaeological surveys be conducted. Table 4.8 summarises further surveys undertaken.

In June 2009, an Agreement for the Protection of Indigenous Heritage for Exploration Activity on the Lake Maitland Project was executed between CDNTS and Mega. Amongst other things, the agreement provided for heritage surveys to be undertaken prior to Mega conducting any ground disturbing activities.

Table 4.8 lists the heritage surveys that subsequently have been undertaken at Lake Maitland.

Table 4.8: Summary of heritage surveys conducted at Lake Maitland

Item	Description
13–16 July 2009	
Purpose and Outcome	An ethnographic survey using a Work Area Clearance method over 'priority' areas for exploration. The survey identified two not-cleared areas. All other areas were cleared for the exploration activities proposed by Mega.
Number of Traditional Owner Informants	The survey was undertaken on foot and by four wheel drive vehicle. The number of informants was not reported.
Date and Title of Survey Report	Heritage Survey Report – Ethnographic Survey – Mega Uranium Lake Maitland Project Tenements E53/1211, P53/1254, P53/1255, P53/1336, E53/1210, P37/6943, P53/1252 and M53/1089. Prepared by Beth Woodward and Lindsey Langford for Central Desert Native Title Services Ltd, July 2009.
November 2009	
Purpose and Outcome	An archaeological work program clearance survey of drill lines and access tracks. All parts of the surveyed drill lines and access tracks were cleared for the proposed ground disturbing activities. 12 areas of cultural significance were recorded as not cleared for any ground disturbing activities. A number of isolated artefacts were also noted, but no modifications were required to the work plan.
Number of Traditional Owner Informants	The survey was undertaken on foot and by four wheel drive vehicle. The number of informants was not reported.
Date and Title of Survey Report	Preliminary Advice in relation to an archaeological work program clearance survey of the Lake Maitland Uranium Project Area – Priority Area Three – November 2009. Survey undertaken by Robin Stevens (consultant).
13–24 July 2010	
Purpose and Outcome	An ethnographic survey and an archaeological survey to examine areas on tenements E37/0970, E53/1211, E53/1212, E53/1441, E53/1442, L53/0152 and M53/1089 on which it was proposed to conduct an exploration drilling program and associated works. Of 13 registered sites noted within the areas surveyed, none would be impacted by the proposed exploration activities. Two areas of ethnographic interest were not cleared. It was recommended that no ground disturbing activity be undertaken within 16 further archaeological sites identified or within 15 metres of 22 significant isolated archaeological finds.
Number of Traditional Owner Informants	A group of Barwidgee People. The number was not recorded in the survey report. The work was undertaken on foot and by four wheel drive vehicle.
Date and Title of Survey Report	Preliminary advice of the results of the heritage survey of the proposed Mega Redport Pty Ltd exploration program at the Lake Maitland Uranium Project east of Leinster, WA. Advice prepared by Stuart Fisher and Joe Dortch, August 2010.

As it continues to develop its relationship with the Barwidgee and other Aboriginal people claiming an interest in Lake Maitland, Toro will undertake further evaluation of cultural heritage issues, including on-ground survey work, where required, to ensure the recognition and protection of cultural heritage. Mega agreed with the Barwidgee People to provide financial support for the registration of a Native Title determination application. Toro has confirmed with the Barwidgee People that it will maintain this commitment and seek to negotiate a mining agreement with all Aboriginal people with an interest in Lake Maitland.

Most of the Barwidgee People with an interest in Lake Maitland live in Kalgoorlie. As well as protection of their cultural heritage, they have advised Toro that they hope to secure employment and business development opportunities from mining at Lake Maitland. Toro is continuing to consult with them about these issues, noting that mining at Lake Maitland, if approved, is unlikely to commence before 2021. As planning continues for mining at Lake Maitland, Toro would implement methods of consultation which mirrored those followed with the Wiluna People.

As the result of a site visit in October 2014, Toro and the Barwidgee People are discussing the establishment of a camping area on the Barwidgee Pastoral Lease to enable younger members of the group to become more familiar with the land and the traditions of their people.

Table 4.9 lists Toro's meetings with the Barwidgee People and their representatives since Toro completed the acquisition of the Lake Maitland Uranium Project in November 2013.

Table 4.9: Meetings between Toro and the Barwidgee People

Date	Purpose and Outcome of Meeting
13 January 2014	Meeting with the Barwidgee People in Kalgoorlie to introduce Toro and provide an initial briefing on its plans for Lake Maitland.
10 June 2014	Meeting with representatives of the Barwidgee People to discuss their business development aspirations, including sandalwood harvesting, and how Toro may be able to support them.
6 July 2014	Meeting with the Barwidgee People in Kalgoorlie to provide update on plans for mining at Lake Maitland and to indicate how Toro may be able to support a sandalwood harvesting proposal.
10 August 2014	Meeting with representatives of the Barwidgee People to plan for a visit to Lake Maitland to discuss heritage and business development issues.
30 September 2014	Cross-cultural awareness workshop provided to Toro staff by Barwidgee People.
25–26 October 2014	Site visit to Lake Maitland.
26 November 2014	Site visit to Lake Maitland with representative of Barwidgee People to discuss water drilling program.
19 May 2015	Meeting with representatives of the Barwidgee People to discuss progress with preparation of a Native Title claim and to provide an update on Toro's current activities.
20 October 2015	Meeting with representatives of the Barwidgee People to discuss status of activities at Lake Maitland.

4.3.6 Regional Issues

In regional consultation, discussions have focused on potential regional health, safety and radiation impacts as a result of both mining and finished product transport, and opportunities for employment and contracting with Toro. These issues are also discussed in Section 19 of this PER.

From its community and stakeholder consultations, Toro is aware of concerns that any strong reliance on fly-in/fly-out workforce arrangements could deny employment and contracting opportunities to local and regional people and businesses. As further discussed in Section 19, during the construction and operational phases of the Proposal, Toro would focus on local and regional recruitment where possible. A priority would be to train people interested in careers in the resources sector rather than seek to attract all operators from elsewhere. To do so would require programs to train and retain the necessary workforce in collaboration with government training and employment initiatives and other relevant providers. Using the model established by industry participation in the Wiluna Regional Partnership Agreement, Toro would also pursue opportunities for cross-company cooperation on workforce planning, training and recruitment.

Toro has given regular briefings to regional business organisations to provide information on the progress of the Proposal and the opportunities that may arise from its implementation.

To date, Toro has used local and regional contractors during the site investigation and exploration phases of the Proposal. Toro is committed to sourcing local and regional labour and contractors to the extent they are available and it is economic to do so.

As a result of discussions with the City of Kalgoorlie-Boulder and wider consultation in Kalgoorlie, Toro has decided that during the transport of finished product, vehicles carrying UOC would not stop in the council area for fuelling or driver change-over, nor would they enter the centre of the city, taking instead the eastern bypass road.

4.3.7 Ongoing Consultation during Assessment Period

The consultation program is continuing throughout the assessment process. The 12 week public exhibition and comment period for the PER is an important opportunity for communities and stakeholders to provide further input to the assessment. While this period is formally a government-led consultation, Toro will continue to respond to public inquiries about the PER and the Proposal more broadly.

Toro will provide further opportunities for communities and stakeholders to seek information about the PER and the Proposal throughout the public exhibition period, including information days in Wiluna, Leonora and Kalgoorlie. The dates will be advertised locally and in regional press.

4.3.8 Consultation during Construction and Operational Phases

If the Proposal is approved, a program of ongoing consultation to identify, monitor and manage issues and impacts would be undertaken as construction work and then operations progressed. Meetings and briefings would be held on a regular basis with government departments and agencies, and key communities and stakeholders. Other consultation methods to be used by Toro would include periodic open days at the mining sites and community information bulletins. In addition to an Aboriginal Liaison and Development Officer, Toro would appoint a Community Relations Manager dedicated to managing day-to-day communication with the wider community and ongoing regional consultation.

Other key elements of ongoing consultation would include the implementation of a Community and Stakeholder Consultation Program through which:

- A register of contact with the communities and stakeholders most likely to be affected by construction and operations would be established (based on existing community and stakeholder identification), maintained and available for government review;
- All those on the communities and stakeholder register would be informed of planned milestones including start to construction, start to commissioning, start to regular production, and subsequent major operational schedules such as start to transport of finished product, transition of mining from Millipede/Centipede to Lake Maitland then Lake Way, and implementation of closure and rehabilitation plans;
- Any major safety or environmental incident would be publicly disclosed in a timely manner;
- The Community Relations Manager would be readily available to the local and regional communities and provide prompt responses to any issues of interest or concern;
- Regular community and stakeholder reporting would be provided on operational, environmental and social performance; and

- A pre-qualification process would ensure the engagement of contractors with an understanding of community and stakeholder concerns and issues.

Toro would commit to the following specific methods to keep communities and stakeholders informed (in addition to any reporting obligations to government and commitments to Aboriginal people in mining agreements):

- The continuation of a Toro Office in Wiluna at which the Community Relations Manager would be readily accessible;
- A quarterly newsletter;
- A half-yearly briefing of members of the Shire of Wiluna Council by senior Toro management (and of members of the Shire of Leonora Council during the construction and mining phases at Lake Maitland);
- A Community Issues Management Procedure to ensure prompt and documented responses to all issues raised with Toro, available for government review;
- An annual open day at Millipede and Lake Maitland for the local community;
- The offer of an annual site visit for non-government organisation representatives;
- An annual report posted on Toro's website on operational, environmental and social performance; the report to be externally audited every three years; and
- Regular provision of information to the local and regional press and media.

5 PROPOSAL JUSTIFICATION AND ALTERNATIVES

This section provides a justification for the Extension to the Wiluna Uranium Project in terms of market demand and supply for uranium and the economic benefits the Proposal can deliver. It also discusses alternatives to the Proposal configuration described in this PER.

5.1 Justification for the Proposal

The major justifications for the proposed Extension to the Wiluna Uranium Project are to:

- Respond to the long-term outlook for increased uranium demand to support global nuclear power generation, to boost Australia's export income;
- Initiate a new industry for Western Australia in uranium mining;
- Provide local and regional employment and business development opportunities;
- Support the community development aspirations of Aboriginal people; and
- Increase royalty income to the Government of Western Australia.

The Proposal would provide benefits, particularly in regional Western Australia, including:

- Employment during construction for up to 350 people and 200 during the operational phase, with flow-on benefits to service industries;
- Employment, training and other benefits to the local Wiluna community, in particular over a longer period, through the extension of the Project and mining agreements with Aboriginal people; and
- Contributions over a longer period to the Western Australian economy resulting from royalties, taxes and the purchase of goods and services.

Australia has more recognized uranium resources than any other country, more than a third of the world's known total. The principal use of uranium is in power generation.

Nuclear power, unlike hydrocarbon fuels (petroleum, natural gas, coal), does not directly generate greenhouse gases and is therefore regarded as an important source of clean energy to combat climate change.

Nuclear power currently accounts for about 11% of total world electricity generation. Nuclear power is used by more than 30 countries and in some it accounts for a very substantial proportion of their power needs. France, for example, derives more than three-quarters of its electricity supply from nuclear fuel and exports nuclear energy to the rest of Europe. Uranium is also used in the production of medical and industrial isotopes.

According to the World Nuclear Association, in April 2015 there were 437 operable civil nuclear power reactors globally, with another 65 under construction, 165 on order or planned and 316 proposed (www.world-nuclear.org.au – World Nuclear Power Reactors and Uranium Requirements – read on 20 May 2015).

Since early 2011, the Australian uranium mining industry has been affected by the suspension of nuclear power in Japan following the Fukushima earthquake and tsunami. This has led to excess uranium supply, keeping prices below the level needed to entice investment in new mines. In the long-term, however, uranium demand is projected to rise to outstrip supply, requiring new mines to be developed.

Nuclear power generating capacity is expected to grow by 60% by 2040 to help meet an expected total global energy demand increase of 37% in that period (WEO, 2014).

China has 27 reactors currently under construction, generating an anticipated approximately 58 gigawatts equivalent of new nuclear power by 2020 with another 64 reactors planned and

123 proposed. Other emerging economies in Asia, most significantly India, South Korea and Russia, are also undertaking active reactor building programs. The United Arab Emirates and Turkey are adopting nuclear as base load power options. There are firm plans for new reactors in Britain. In September 2014, Toro's Managing Director, Dr Vanessa Guthrie, participated in a business delegation to India led by the Australian Prime Minister during which the India-Australia Nuclear Civil Cooperation Agreement was signed. Subsequently, Dr Guthrie was appointed to the Australia-India CEO Forum, a high level business group jointly established by the Australian and Indian Prime Ministers to help drive the bilateral economic relationship between their countries. India and Australia are finalising bilateral safeguards arrangements to enable Australia's uranium to be exported to that huge electricity market.

With new mines having been deferred in recent years due to prices trading well below incentive levels for new production, it is inevitable that a supply-side shortfall will be realised. This is expected to be exacerbated in the coming years with the recent end of the Russian-United States Highly Enriched Uranium agreement causing secondary market supplies to dwindle. Current forecasts are for a shortfall of new supply to occur from 2017 onwards. Toro's strategy has been to position itself to be able to come into production at a time when uranium prices are forecast to respond to demand outstripping supply over the second half of the decade.

5.2 Alternatives to the Proposal

5.2.1 Mining

The location and extent of the proposed mining at Millipede and Lake Maitland are dictated by the occurrence of uranium mineralisation. There are no alternatives to the proposed location of the mine pits.

There are three general methods of uranium mining: underground, open cut and in situ leaching and recovery. The latter method involves pumping a complexing agent and oxidant into the ore body to leach the uranium and recover the pregnant liquor for processing and is only applicable to certain types of deposits that have contained aquifers. The Millipede and Lake Maitland deposits are too shallow to justify underground and are not suitable for in situ methods. The method proposed by Toro for Millipede and Lake Maitland is shallow open cut, the same as that already assessed for mining at Centipede and Lake Way (EPA Assessment 1819 and EPBC 2009/5174).

When uranium is mined using open cut methods, it is often excavated using large trucks and shovels. Sometimes blasting is necessary to break up the rock before it can be excavated. No blasting would be required at Millipede or Lake Maitland as the ore occurs in relatively thin layers of low to medium strength rock. Toro would use a machine called a surface miner to enable selective mining of the uranium ore. The surface miner is a tracked vehicle with a cutting drum which breaks up the ore.

Toro proposes to separate ore from non-mineralised material through grade control drilling and in-pit ore spotting by mining operations personnel, supported by using a calibrated radiation detection device. Material registering a radiation level above the minimum ore grade would be excavated and sent for processing. Non-mineralised material would be set aside and backfilled into the pit from which it came, or other pits that require fill, once all ore had been removed and once tailings (at Millipede) have had time to consolidate. The proposed mining method would increase operational efficiency by reducing material handling, fuel use and reagent use.

5.2.2 Water Use and Management

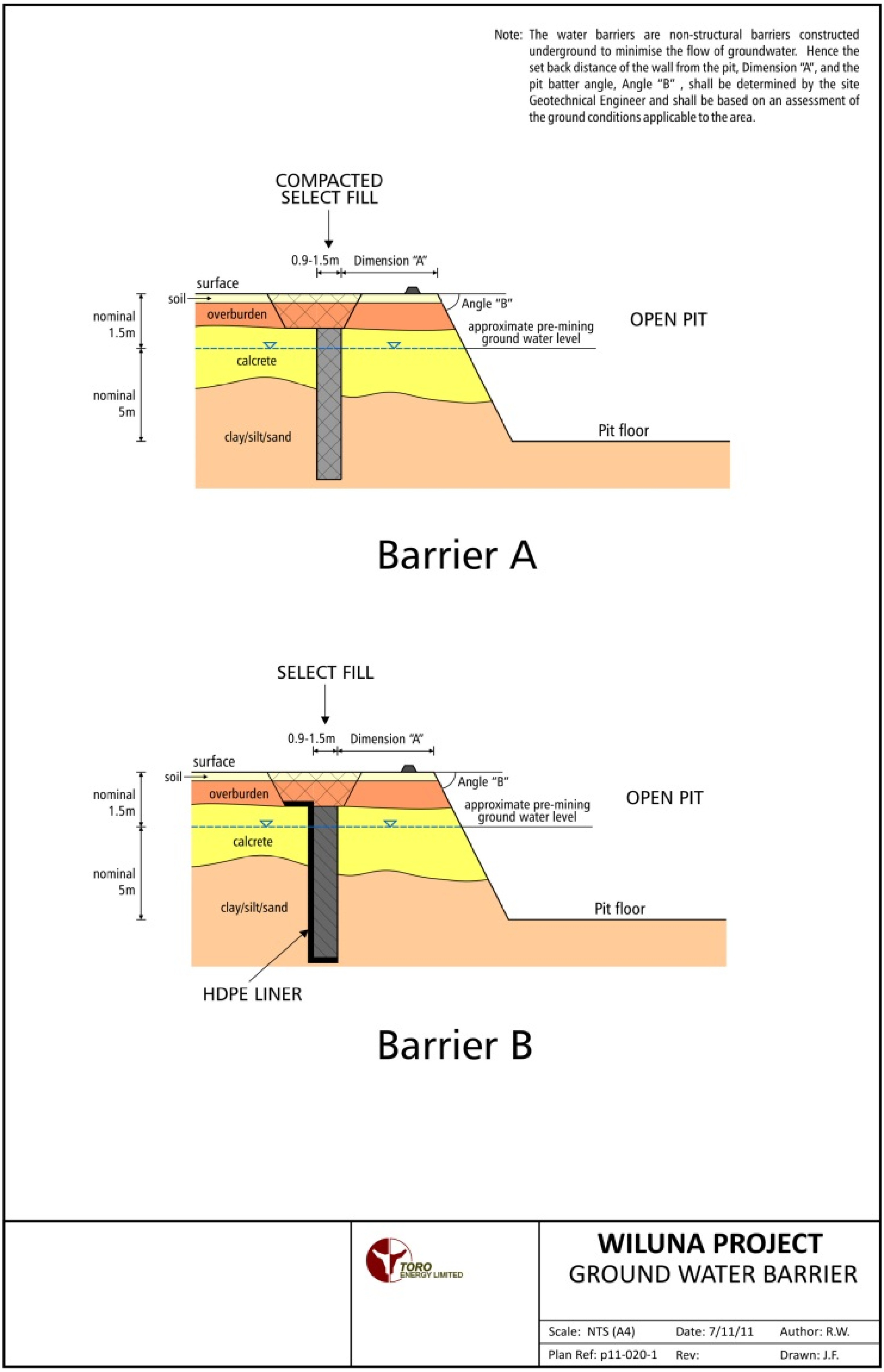
The mineralised ore at Millipede and Lake Maitland lies at or slightly below the water table. Before the ore is extracted, the groundwater needs to be removed from the pit to allow the safe operation of mining equipment.

In most conventional mining operations, pit dewatering is achieved by pumping water from in-pit sumps or by pumping water from bores located around the pit perimeter. Sometimes a combination of both methods is used.

Toro examined the feasibility of using conventional dewatering methods at Centipede and Lake Way, but concluded that its preferred method of managing water flow into the pit would be to construct low permeability barriers around the perimeter of each mining block to limit water ingress into the mine pit. This method shown in Figure 5.1 was included in EPA Assessment 1819 and EPBC 2009/5174 for Centipede and Lake Way and would be adopted for mining at Millipede and Lake Maitland. The method is based on barrier trials showing water inflow can be significantly reduced. Toro has determined that use of the method demonstrated in **Barrier A** (Figure 5.1) would be the most effective for groundwater management.

The mining areas at Millipede and Lake Maitland would be constructed with low permeability clay water barriers. Some collection of groundwater from in-pit sumps would be required at Millipede and Lake Maitland. The groundwater from in-pit sumps, which is expected to be hypersaline, would be used in ore processing to the extent practicable. If more water is collected than can be used in the processing of ore, the surplus water would either be used for other purposes (e.g. control of dust within the mine pits) or would be disposed of by means of evaporation or reinjection into the aquifer from which the water came. Although some mines in Western Australia dispose of saline water from mine dewatering by releasing it to the surface of a nearby salt lake, Toro does not propose to discharge groundwater to either Lake Way or to Lake Maitland.

Figure 5.1: Water barrier construction diagram – Barrier A



Mine Closure

As part of the rehabilitation of the mine pits, space would be allowed to contain any materials that cannot be taken off site. This may include items such as pipes and part of the plant that cannot be decontaminated and therefore must be buried on site. Decommissioning of the processing plant and the accommodation camp was included in EPA Assessment 1819.

The infrastructure to support mining at Millipede would be the same as that required for Centipede. There are no additional installations apart from internal haul roads needed to facilitate mining at Millipede. For this reason, there are no waste materials (such as concrete and steel) that would need to be removed from Millipede that are additional to those to be removed from Centipede. The roads put in place to connect the two deposits would be ripped up and re-spread with topsoil and revegetation, where required.

The underground pipeline connecting the processing plant with the Lake Maitland borefield would likely be left in place. The advantage of this is that after installation the area cleared for the pipeline would be rehabilitated and have had almost 20 years to recover. Removal of the pipeline at that stage could interrupt ecosystems and spread weeds. Accordingly, the environmental benefits of leaving the pipeline in place outweigh any benefits of its removal. Infrastructure at each end of the pipeline would be removed.

The haul road connecting Lake Maitland to the processing plant would be rehabilitated by ripping, spreading with topsoil and revegetated, if required. As this haul road would not be required beyond Year 13 of the operation, it is likely that this rehabilitation would take place well in advance of Project closure.

At the Lake Maitland site, all above ground installations such as workshops, the accommodation camp and any office buildings would be removed. It is likely that the office buildings and camp would be sold and taken off site. Similarly, workshops are also likely to be removed from site as they would not be contaminated beyond the point of remediation. Fuel tanks and other hydrocarbon storage containers would be taken back to the workshop at Centipede where they would be used for the remainder of the Project's life. During operations at Lake Maitland, all rubbish and waste hydrocarbons would be sent to the Centipede site for disposal and/or remediation.

It is likely that concrete footings at Lake Maitland would need to be disposed of inside the mine pit. The volume of concrete to be removed has been estimated based on the approximate footprint of the mine buildings and is presented below in Table 5.1. The engineered pads on which the stockpiles would sit are likely to be compacted clay and are not included within the calculation. These are also likely to be disposed of within the pit.

Table 5.1: Materials and waste to be managed at Lake Maitland at the end of mine life

Installation	Footprint	Approximate Volume of Concrete to be Removed
Mine workshops	2 ha area allowed for workshop floors	2000 m^3
Mine camp and offices	20 dongas, plus footpaths, parking and associated infrastructure	520 m^3

5.2.3 Processing

Ore mined at Millipede and Lake Maitland would be processed at the plant already assessed for processing ore mined at Centipede and Lake Way (EPA Assessment 1819 and EPBC 2009/5174). The processing method would be the same for ore from all four deposits and the capacity of the plant would not change, although it would operate for longer to process all ore mined during the life of the Project.

A range of alternative methods can be used to extract uranium from ore. The method adopted depends upon a number of factors, including the mineralogy of the ore body, the physical characteristics of the ore and the grade of the ore.

Uranium is extracted from the ore by treating it with a chemical reagent to dissolve the uranium. The solution containing the uranium is then treated to concentrate the uranium into a solid material and remove impurities. The conventional process of extracting uranium involves leaching the ore in an industrial vessel or vat. Normally, this requires crushing and grinding of the ore and stirring of the ore solution as it is extracted. In-vessel leaching may be carried out at elevated pressure or temperature. Alternatively, ore can be extracted at normal atmospheric pressures and temperatures on an engineered liner. This process, known as heap leach, takes much longer to extract the uranium with lower recovery rates.

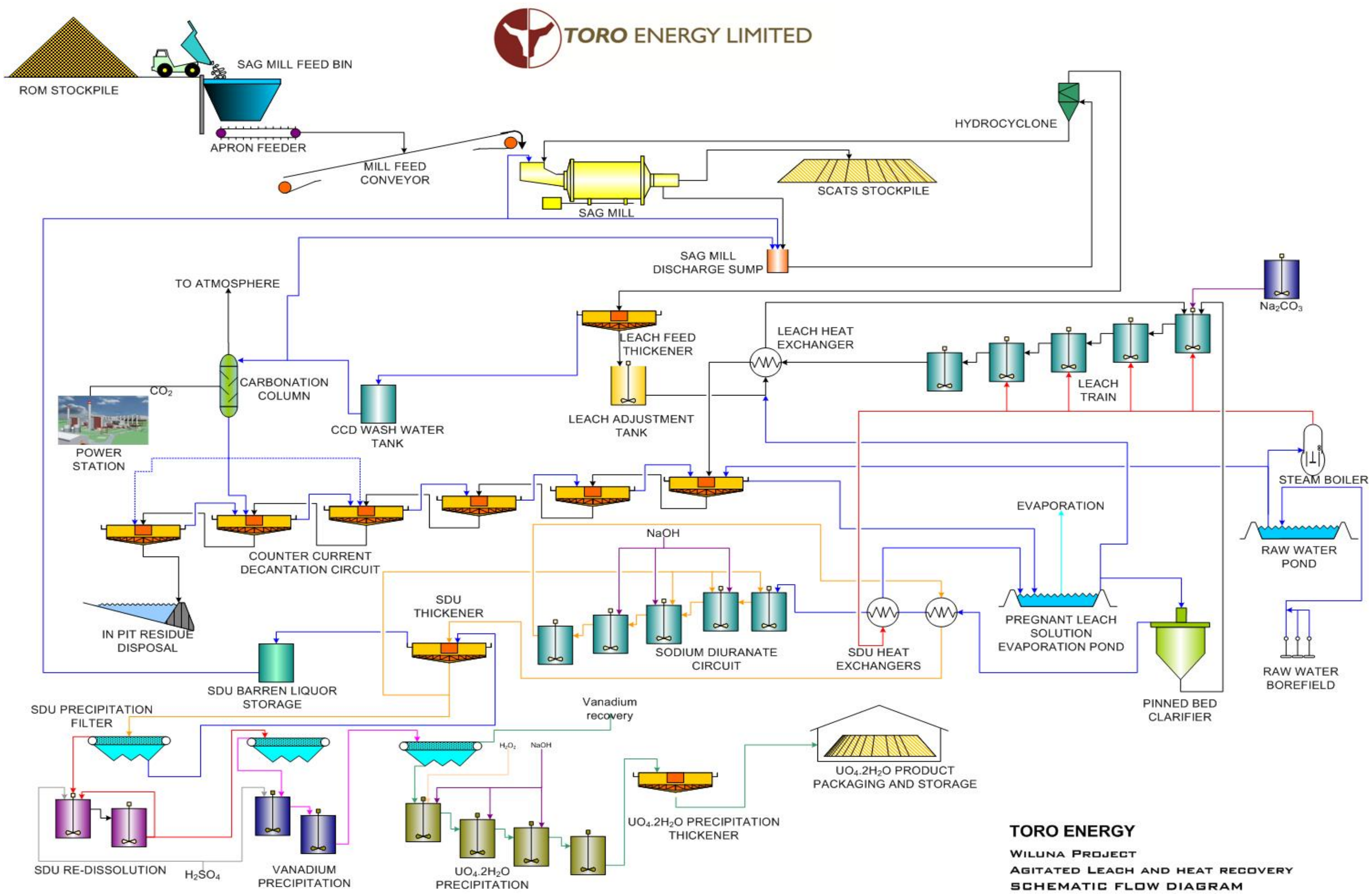
Two main types of chemical reagents are used in uranium processing: acids and alkalis.

Toro would use an alkaline extracting solution, sodium carbonate. Acid leaching would not be economically feasible, due to the large acid consuming components in the calcrete and clay ore.

Toro has intensively studied the less conventional heap leach extraction method, which would involve recirculating carbonate solution over piles of ore placed on an engineered liner. Toro has concluded that the agitated leach process (Figure 5.2) is more suited to processing of uranium from all of its deposits because:

- The alkaline agitated leach process is proven and is in commercial use;
- Agitated leach provides better process control and a better metallurgical recovery (approximately 86% compared with heap leach recovery of approximately 70%); and
- The agitated leach process delivers the end product within a short period of time (a few days), whereas heap leach has an extended leach time (+400 days) before product is available.

Figure 5.2: Process flow diagram



5.2.4 Plant Site Options

The plant facility and supporting infrastructure (offices, ablutions, power supply, warehouse, product packaging area, etc.) need to be located in close proximity to mining areas where possible, but on land that would not be mined. Toro considered a number of potential plant locations prior to submitting its proposal for mining of the Centipede and Lake Way deposits. The location assessed (EPA Assessment 1819 and EPBC 2009/5174) is also the optimum site for mining at Millipede and Lake Maitland. This configuration would eliminate the need for a processing plant at Lake Maitland as proposed by Mega.

The chosen location of the processing plant has the following additional advantages:

- It is the most central for all the deposits for which Toro holds tenure;
- It minimises the haulage of ore providing safety, environmental and cost benefits;
- It is about 8 km east of the Goldfields Highway, enhancing security of the site;
- It is about 30 km south of Wiluna and the nearest residences, reducing the potential for safety and environmental impacts to the public from the plant's operation; and
- It reduces the Project footprint, consolidating operational management at one location.

5.2.5 Process Waste Management

In conventional open pit mining, as proposed for the Extension to the Wiluna Uranium Project, it is common to store overburden in above ground facilities. By-product from ore processing ('tailings') is sometimes placed in engineered storage facilities or may be placed within the waste rock dump. In developing the original Wiluna Uranium Proposal for mining at Centipede and Lake Way (EPA Assessment 1819 and EPBC 2009/5174), Toro considered four potential options for establishing a Tailings Storage Facility (TSF). They were:

- Above ground valley configuration: This was considered unsuitable, as the area in which the Proposal would be developed is relatively flat, so there are no suitable sites for an above ground valley storage.
- Four-sided 'above ground style' facility: There are large flat areas on the site close to the plant both on Lake Way itself and on the surrounding area. While a four-sided facility would be viable, Toro believes below ground storage represents better practice and this is validated by continuing industry research and practice. In making this assessment, Toro also took particularly careful account of the wishes of Traditional Owners that the Proposal not alter existing landforms in the long term and not impinge in any significant way upon the surface of the Lake Way playa itself.
- Below ground storage in an existing pit: In-pit storage of tailings has been used by other mining operations in the Wiluna area (mainly gold). There is only one existing pit in the area around Lake Way that would be suitable for disposal of tailings (an abandoned gold mine). It is approximately half way between the Centipede and Lake Way deposits. However, the pit was determined as too small to be viable as a storage facility.
- Below ground storage in mining voids: As discussed in Section 6, this option is considered representative of best practice tailings management.

The in-pit disposal method approved under Ministerial Statement No. 913 would also be used for disposal of tailings arising from the processing of ore from the Millipede and Lake Maitland deposits. Like Centipede, the Millipede pit would be relatively shallow and mined in compartments to enable an area of the pit to be available for tailings storage from the beginning of the plant operation. Ultimately, the Centipede and Millipede pits will join. The volume of overburden, waste and ore removed during mining at Centipede and Millipede would be sufficient to allow all tailings from the processing of Centipede, Lake Way, Millipede and Lake Maitland ore to be stored below ground level. No tailings would be disposed of at Lake Maitland.

To adopt this in-pit option naturally limits the configuration of the TSF to the mine voids. Within this configuration, other design considerations that were required included the thickness of the tailings cover, the requirement for a low permeability liner on the base, and the design of the water barriers to prevent groundwater ingress both during operations and post-closure.

With the proposed in-pit tailings configuration, mining of the voids would continue below the ore and at sufficient depth to ensure mitigation of radon by the tailings cap. The depth of the tailings disposal (i.e. at up to 15 m below surface) is dictated by the depth of the ore body and underlying natural clays. Mining would occur below the ore body to a depth that ensured the underlying clays were sufficiently available to form a 300 mm compacted clay base liner and with sufficient volume to ensure that all of the tailings would be disposed of below the natural ground surface.

The tailings cover design is based on radon emanation criteria and, consequently, would be approximately 2 m thick (refer Section 16). This thickness is also sufficient to reduce any risk of plant root penetration and invasive species reaching the tailings, particularly given the multi-layer design as outlined in Section 6. In many places the tailings cover would be over 3 m due to the shaping and reconstruction of the landform, including the re-establishment of sand dunes at the margins of the mining footprint.

There are a number of other benefits to the proposed back-filling of pits, including:

- Lower visual impact;
- Lower risk of creating permanent unnatural water bodies that might attract feral animals or other herbivores;
- Lower risk of trapping animals in open mine voids;
- Less alteration to local hydrology;
- Lower risk of erosion and sediment transport; and
- Lower risk of surface release of radon or gamma radiation from the pit voids.

5.2.6 Finished Product Shipping, Storage and Distribution

The option of exporting finished product from a Western Australian port has not been considered because of a policy decision by the Western Australian Government not to permit transport of uranium for export to ports surrounded by residential areas.

At present, only Port Adelaide and Darwin Port are used for export of uranium from Australia. To access them, Toro would transport product by road out of Western Australia using the Goldfields and Eyre Highways. This method has been assessed (EPA Assessment 1819 and EPBC 2009/5174). The rate of finished product transport, averaging five shipping containers per month for mining at Centipede and Lake Way, would not increase, but transport would occur over a longer period with mining at Millipede and Lake Maitland. Port Adelaide and Darwin Port have been used for almost 30 years to ship out uranium from the Olympic Dam, Beverley and Ranger uranium mines.

5.2.7 Workforce Accommodation

Mining at Millipede does not create any construction or operational personnel additional to those required for mining at Centipede. The village accommodating construction and operational personnel for Centipede would also accommodate Millipede personnel. The option of accommodating all Lake Maitland employees and contractors at the same village was considered. However, for those employed at Lake Maitland, this would involve a daily round trip of almost 200 km. A separate accommodation camp would be established at Lake Maitland for its construction and operational workforces.

6 THE PROPOSAL

This section discusses the major components of the Extension to the Wiluna Uranium Project which Toro proposes to implement. The key impacts associated with the Proposal have been identified and are discussed in Sections 9 through 17.

6.1 Overview of the Proposal

An overview of the Proposal is given in Table 6.1.

Table 6.1: Summary of the Proposal

Proposal Title	Extension to the Wiluna Uranium Project
Proponent Name	Toro Energy Limited
Short Description	The mining of uranium at Millipede and Lake Maitland, respectively 30 km south and 105 km south-east of Wiluna, Western Australia, the construction of roads, power and water source and supply facilities and other associated infrastructure, and discharge of waste to an in-pit TSF.
Life of Proposal	In excess of 12 years, including construction, operations and closure.
Project Timing	Subject to regulatory approvals, financing and market conditions, construction could commence at Millipede by no earlier than late 2016 and at Lake Maitland by 2021 with mining at both locations to begin within two years of construction commencement.
Estimated total ground disturbance	No more than 1581.8 ha: Millipede 537.9 ha; Lake Maitland 1043.9 ha including haul road corridor between Lake Maitland and the processing plant.
Mining Method	Open pit using surface miners and heavy machinery mining to a depth of approximately 15 m.
Processing Method	Use of already approved plant: crushing and grinding followed by elevated temperature agitated alkaline leach (in tanks), solid/liquid separation and direct precipitation of uranium oxide concentrate.
Tailings Management	In-pit disposal at Millipede.
Mine Rehabilitation	Progressive rehabilitation during mining with land re-contoured to blend with local terrain and revegetated using local provenance species.
Finished Product Transport	By road via Goldfields Highway, Eyre Highway and other existing roads to Adelaide and by rail between Adelaide and Darwin.

Table 6.2 lists an indicative schedule for implementation of the Proposal should approval be granted for mining at Millipede and Lake Maitland and Toro's Board be able to make a final investment decision in late 2016.

Table 6.2: Indicative schedule for implementation of the proposal

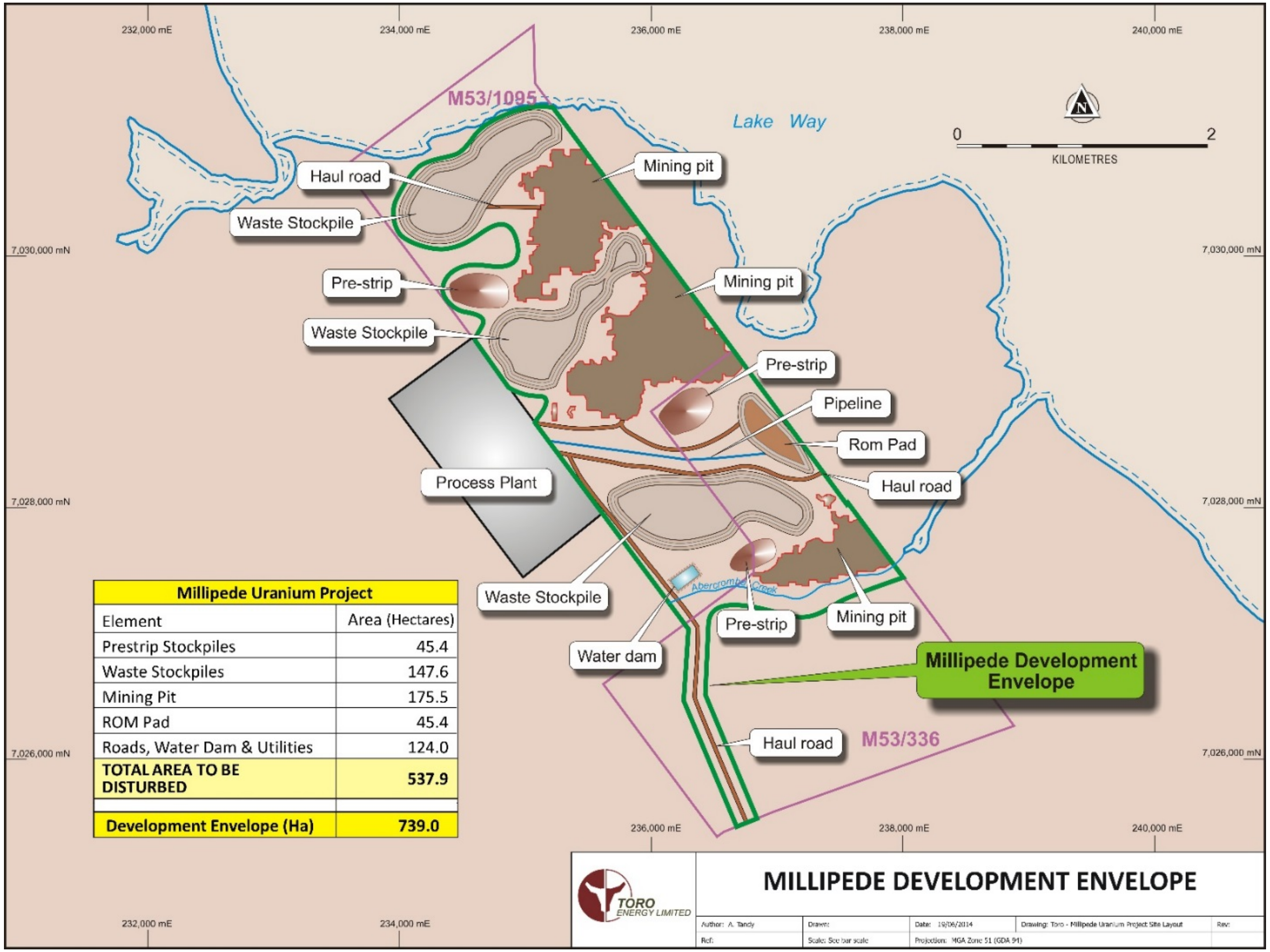
Deposit	Potential Commencement of Mine Development	Completion (Including Mine Closure and Rehabilitation)
Millipede (this assessment)	No earlier than late 2016	2023
Centipede (EPA Assessment 1819 and EPBC 2009/5174)	No earlier than late 2016	2023
Lake Maitland (this assessment)	2021	2028
Lake Way (EPA Assessment 1819 and EPBC 2009/5174)	2028	2038

The key design and operational characteristics of the Extension to the Wiluna Uranium Project are summarised in Table 6.3 to Table 6.6 and illustrated in Figure 6.1 to Figure 6.4. The latitude and longitude of the Proposal are listed in Appendix 2.

Table 6.3: Physical Elements – Millipede

Element	Location	Proposed Extent Authorised for the Revised Proposal	Extent Authorised of the Approved Proposal	Total Proposed Extent Authorised of the Entire Proposal
Mine	Figure 6.1 and geographic coordinates as described in Appendix 2.	No more than 175.5 ha of disturbance for mining (including in-pit tailings storage) within a 739 ha development envelope	Centipede Mining Area (M53/224) – clearing of up to 700 ha of vegetation, including 280 ha of low heath vegetation unit with *Tecticornia* species. Lake Way Mining Area – clearing of up to 580 ha of vegetation, including 340 ha of low heath vegetation unit with *Tecticornia* species.	No more than 1455.5 ha of disturbance (for mining at Millipede (M53/1095 and M53/336), Centipede (M53/224) and Lake Way (M53/1090), including in-pit tailings storage).
Associated infrastructure	Figure 6.1 and geographic coordinates as described in Appendix 2.	No more than 362.4 ha of disturbance for pre-strip stockpiles (45.4 ha), waste stockpiles (147.6 ha), run-of-mine (ROM) pad (45.4 ha) and roads, water dam and utilities (124 ha) within a development envelope of 739 ha.	Clearing of up to 250 ha of vegetation.	No more than 612.4 ha of disturbance.

Figure 6.1: Millipede Development Envelope

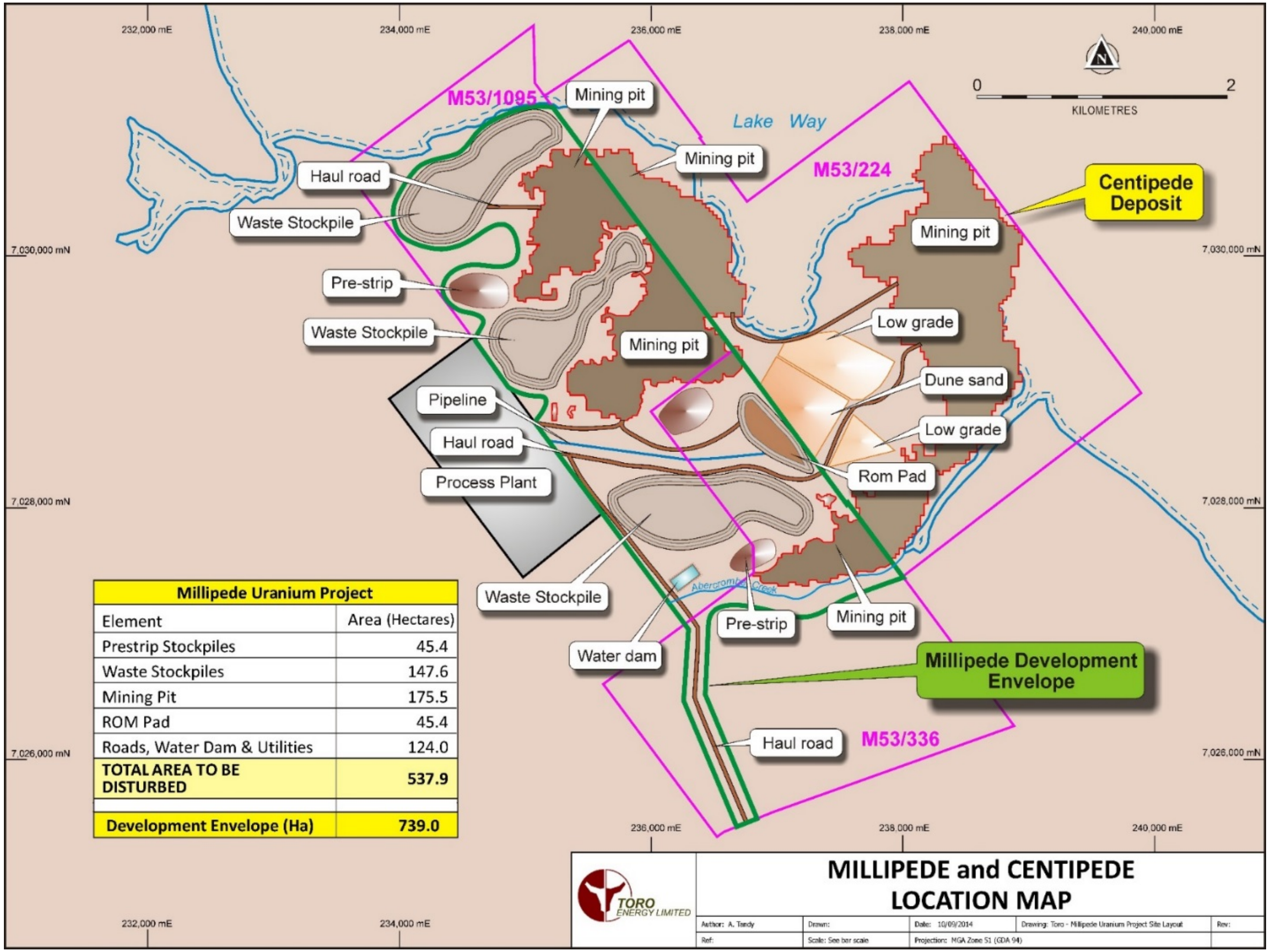


Millipede Uranium Project	
Element	Area (Hectares)
Prestrip Stockpiles	45.4
Waste Stockpiles	147.6
Mining Pit	175.5
ROM Pad	45.4
Roads, Water Dam & Utilities	124.0
TOTAL AREA TO BE DISTURBED	**537.9**
Development Envelope (Ha)	**739.0**

Table 6.4: Operational Elements – Millipede

Element	Location	Proposed Extent Authorised for the Revised Proposal	Extent Authorised of the Approved Proposal	Total Proposed Extent Authorised of the Entire Proposal
Ore Processing (Tailings)	Figure 6.2 and geographic coordinates as described in Appendix 2.	Disposal of no more than 2.1 million tonnes per annum (Mtpa) from mining ore extracted at both Millipede and Lake Maitland.	Disposal of no more than 2.1 Mtpa from mining ore extracted at Centipede and Lake Way.	Disposal of no more than 2.1 Mtpa for the entire life of the Proposal.
Dewatering	Figure 6.2 and geographic coordinates as described in Appendix 2.	Abstraction of no more than 2 Gigalitres per annum (GL/a).	No more than 1.8 GL/a. from dewatering the Centipede and Lake Way deposits.	Abstraction of no more than 2 GL/a. from dewatering the Millipede deposit and no more than 1.8 GL/a. from the Centipede and Lake Way deposits.

Figure 6.2: Millipede-Centipede Location

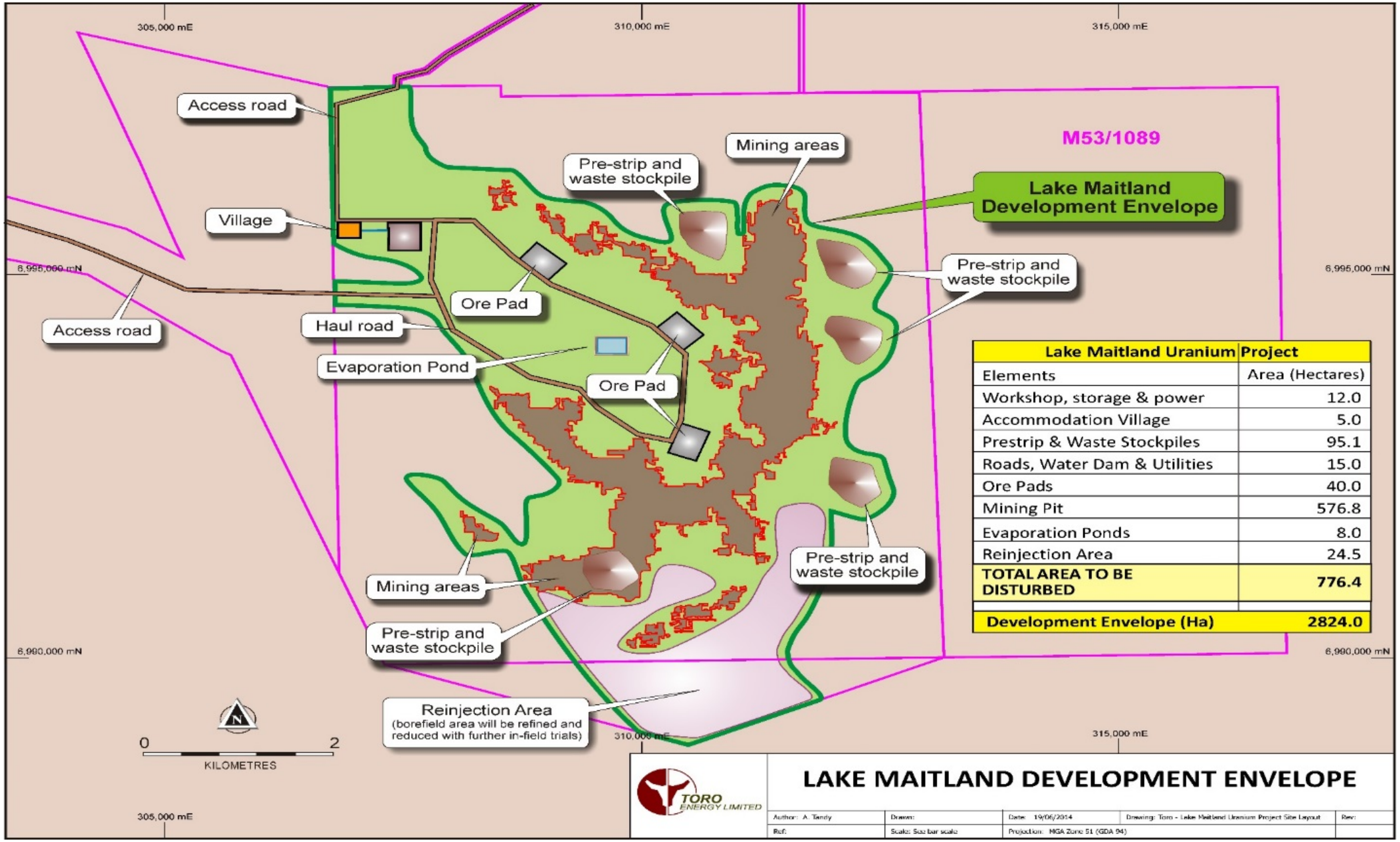


Millipede Uranium Project	
Element	Area (Hectares)
Prestrip Stockpiles	45.4
Waste Stockpiles	147.6
Mining Pit	175.5
ROM Pad	45.4
Roads, Water Dam & Utilities	124.0
TOTAL AREA TO BE DISTURBED	**537.9**
Development Envelope (Ha)	**739.0**

Table 6.5: Physical Elements – Lake Maitland

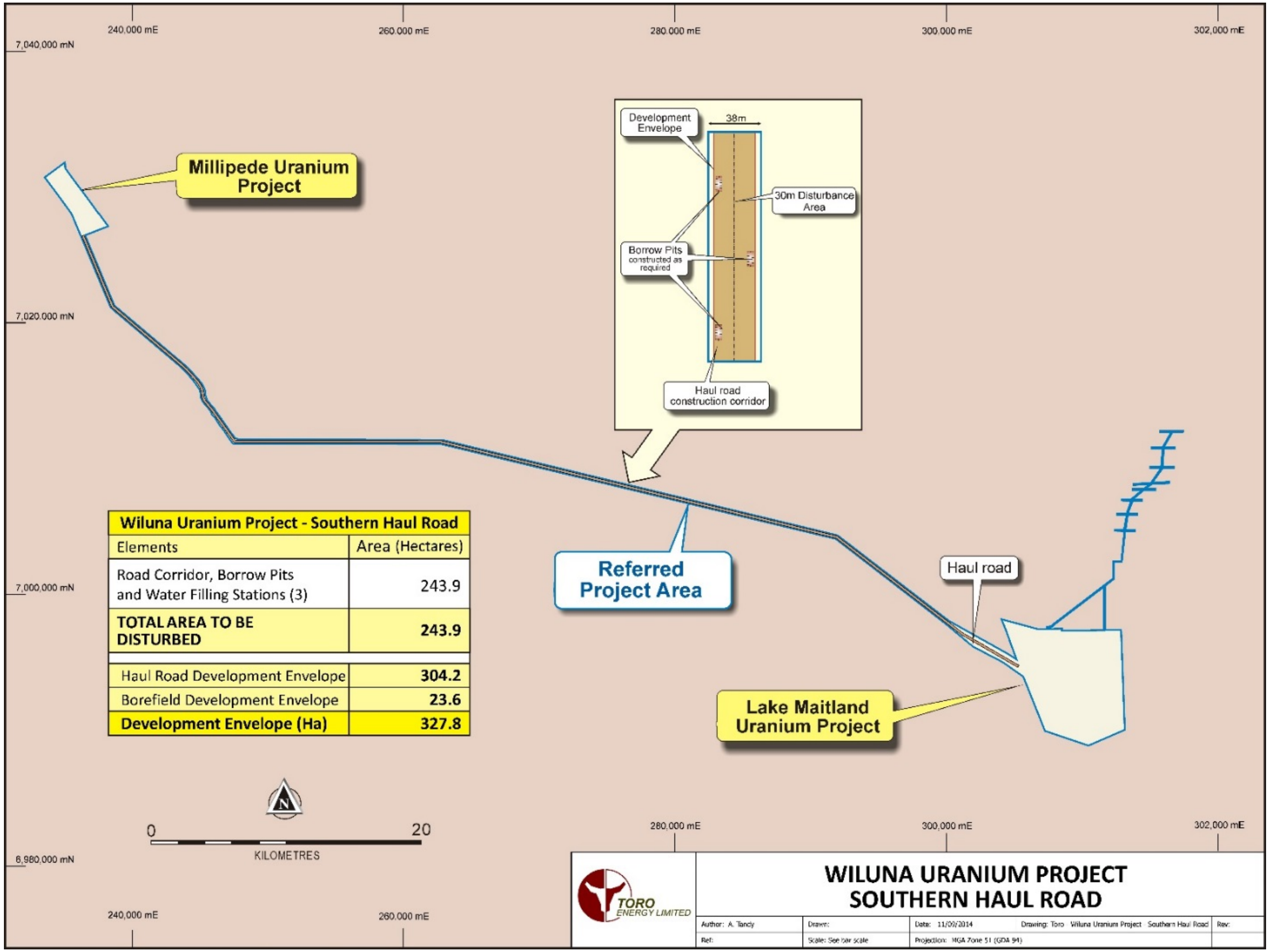
Element	Location	Proposed Extent Authorised for the Revised Proposal	Extent Authorised of the Approved Proposal	Total Proposed Extent Authorised of the Entire Proposal
Mine	Figure 6.3 and geographic coordinates as described in Appendix 2.	No more than 576.8 ha of disturbance within a development envelope of 2824 ha.	Not applicable (N/A) – no authorization has yet been given for mining at Lake Maitland.	No more than 576.8 ha of disturbance for mining at Lake Maitland.
Associated Infrastructure	Figure 6.3; Figure 6.4 (Lake Maitland borefield access road); and geographic coordinates as described in Appendix 2.	No more than 199.6 ha of disturbance within a development envelope of 2475 ha for associated infrastructure including workshop, storage and power (12 ha); accommodation village (5 ha); pre-strip and waste stockpiles (95.5 ha); roads, water dam and utilities (15 ha); ore pads (40 ha); evaporation ponds (8 ha); reinjection borefield (24.5 ha).	N/A	No more than 199.6 ha of disturbance.
Southern Haul Road	Figure 6.4 and geographic coordinates as described in Appendix 2.	No more than 267.5 ha of disturbance within a 330 ha development envelope (243.9 ha for road corridor, borrow pits and water filling stations; 23.6 ha for borefield and access road).	N/A	No more than 267.5 ha of disturbance.

Figure 6.3: Lake Maitland Development Envelope



Lake Maitland Uranium Project	
Elements	Area (Hectares)
Workshop, storage & power	12.0
Accommodation Village	5.0
Prestrip & Waste Stockpiles	95.1
Roads, Water Dam & Utilities	15.0
Ore Pads	40.0
Mining Pit	576.8
Evaporation Ponds	8.0
Reinjection Area	24.5
TOTAL AREA TO BE DISTURBED	**776.4**
Development Envelope (Ha)	**2824.0**

Figure 6.4: Haul Road Alignment – Lake Maitland to Processing Plant



Wiluna Uranium Project - Southern Haul Road	
Elements	Area (Hectares)
Road Corridor, Borrow Pits and Water Filling Stations (3)	243.9
TOTAL AREA TO BE DISTURBED	**243.9**
Haul Road Development Envelope	**304.2**
Borefield Development Envelope	**23.6**
Development Envelope (Ha)	**327.8**

Table 6.6: Operational Elements – Lake Maitland

Element	Location	Proposed Extent Authorised	Extent Authorised of the Approved Proposal	Total Authorised Extent of Entire Proposal
Dewatering	Figure 6.3 and geographic coordinates as described in Appendix 2.	Abstraction of no more than 4 GL/a. during dewatering of the Lake Maitland deposit.	N/A	Abstraction of no more than 4 GL/a. during dewatering of the Lake Maitland deposit.
Aquifer Reinjection	Figure 6.3 and geographic coordinates as described in Appendix 2. The area delineated as the reinjection borefield has been sized to capture the shallow and deep aquifers in the area that will be used to determine the best aquifer in which to reinject. This area will be reduced as field tests determine the size and nature of the reinjection process.	Downstream aquifer reinjection of no more than 4 GL/a. of excess water from pit dewatering.	N/A	Downstream aquifer reinjection of no more than 4 GL/a. of excess water from pit dewatering. Disturbance area to be 24.5 ha maximum. If possible, reinjection will be into the same aquifer as abstraction occurred.
Water Supply	Figure 6.3 and geographic coordinates as described in Appendix 2.	Water supply of no more than 1.5 GL/a.	N/A	Water supply of no more than 1.5 GL/a.

6.2 Site Preparation

Site preparation for both deposits would consist of the progressive clearing of vegetation and top soil prior to mining. Vegetation and top soil would be stockpiled separately to ensure maximum reuse of these resources in subsequent rehabilitation. Toro would leave areas undisturbed for as long as practicable, and then ensure that rehabilitation of disturbed areas occurs as soon as practicable after the areas are no longer required for mining operations. Progressive rehabilitation and the direct return of topsoils and vegetation would be planned and implemented to ensure the highest standards of rehabilitation are achieved.

6.3 Mining

6.3.1 Millipede

The mineralisation at Millipede is contained within zones lying at between 1 m and 15 m below the land surface. The ore body varies in thickness up to a maximum of about 6.5 m. The mineralised zones are laterally extensive, but vertically can be irregular with some areas of very low grade or barren material occurring within the overall mineralised zones. The detailed geology shows that the mineralisation is hosted within a typical fluviatile/deltaic sequence of shallow sediments ranging from narrow clay layers to areas of coarse sand and gravels with minimal clay.

The shallow nature and areal extent of the resource mean that it can be mined in sections by open pit in the same way as that already assessed for mining of the Centipede and Lake Way deposits (EPA Assessment 1819 and EPBC 2009/5174). The mining method selected is based on surface miners for ore fragmentation and a conventional excavator and mine truck load and haul fleet. The haul trucks would be specially equipped to allow trafficking across wet and slippery ground conditions. Mining operations would be continuous, 24 hours a day, 7 days a week. Ore mining would be achieved using the Surface Miner cutting 0.25 m benches in ore with loading of ore into mine trucks while waste mining would be completed on 1 m to 2 m benches using excavators and mine trucks. No drilling or blasting would be required due to the soft ground conditions.

The surface miners can mine very thin layers of material. They are well suited to mining relatively low strength materials and offer particular advantages in situations where variable ore grades necessitate selective excavation to segregate mineralised and non-mineralised materials. A calibrated radiation device would be used to separate ore from non-mineralised material. Material that registered a radiation level above the minimum ore grade would be excavated and sent for processing. Non-mineralised material would be set aside and backfilled. This method would increase operational efficiency by reducing material handling and use of fuel and reagents.

The typical fleet during mining, which may be increased or decreased due to operational requirements, would consist of:

- Up to two surface miners;
- One 100 t excavator;
- Two front end loaders;
- Up to eight 80 t off-highway dump trucks;
- Water carts for dust suppression;
- One grader; and
- Up to three bulldozers.

The dump trucks would transport the ore to one or more bulk stockpile areas where the ore would be temporarily stockpiled before being reloaded and transported in more conventional trucks to the run-of-mine (ROM) pad at the processing plant. Ore blending may occur at the bulk ore stockpile locations or at the ROM pad. In the event that the ground conditions after topsoil clearing resulted in very poor traffic characteristics, granular sheeting would be added, sourced from local or regional borrow pits.

The mining rate would be sufficient to deliver up to 1.3 Mtpa of ore to the processing plant for a life of about five years. Waste rock would be either stockpiled next to the pit being mined or backfilled into suitable nearby mined-out areas. Surface soil cover would be mined and stockpiled separately to be placed over the areas of backfilled pits as part of progressive rehabilitation.

Where possible, internal mine roads and services would be established over areas to be mined or that have been mined to reduce the overall area of disturbance.

At closure, the surface topography would be similar to the pre-mining landscape. If deemed necessary, excess waste rock material that is not considered ore grade would be trucked to Lake Maitland to ensure land forms at mine closure resemble, as much as practicable, land forms that existed before mining.

In a method already assessed for mining at Centipede (EPA Assessment 1819 and EPBC 2009/5174), the mined-out voids at Millipede would be used for tailings storage. It is also proposed that mined-out voids at Millipede would be used to store tailings from processing of ore mined at Lake Maitland. Above ground storage of tailings is not proposed.

To facilitate tailings storage at Millipede, mining operations would start up to a year ahead of processing to allow for construction of tailings storage cells within the pit. As sections of the pit are mined-out, a perimeter wall would be constructed to facilitate tailings management. Internal walls would also be constructed to allow for better water and settling management. These walls would be constructed in compacted layers from waste material. Tailings would be deposited into the cells from multiple points around the perimeter. Excess water would either be returned to the process plant, or be subject to evaporation. The perimeter wall would sit outside the pit enabling a perimeter drain to be constructed. This would facilitate monitoring and management of any seepage from the stored tailings.

Tailings would be deposited below the natural grade of the land. Once the tailings have dried sufficiently to operate machinery on the area safely, they would be capped with waste rock material and the radon capping layer and rehabilitated to a form similar to the surrounding landforms.

6.3.2 Lake Maitland

The mining method would be the same as that proposed for Millipede and at the already assessed Centipede and Lake Way deposits (EPA Assessment 1819 and EPBC 2009/5174) with no drilling or blasting required. The mining rate would be sufficient to provide 1.3 Mtpa of ore to the processing plant.

The uranium deposit proposed to be mined is located along the western margin of Lake Maitland and is essentially crescent-shaped with three arms representing the palaeodrainage channels extending towards the north-west. The deposit is approximately 6 km long (north-south) and up to 4 km wide (east-west). The uranium mineralisation is flat-lying and thin, averaging 1.9 m (range 0.5 m to 4.5 m) in thickness. It generally occurs within a single coherent horizon located 1.5 m to 5.0 m below the surface of Lake Maitland. The mineralisation occurs predominantly as carnotite, a hydrated uranyl vanadate and is primarily hosted within the carbonates and calcareous clays, the magnesium clays, as well as in the upper parts of the kaolinitic clays, clayey sands and sandy clays. The gypsiferous clays and carbonaceous mudstone contain only low levels of uranium mineralisation.

The uranium and vanadium contained in the Lake Maitland ore body originated, respectively, in the Archaean granitic and greenstone country rocks from which the transported lake sediments are derived. Precipitation of carnotite occurred as transporting fluids become depleted in carbonate and concentrated in vanadium through evaporation.

Waste rock produced by mining would be stockpiled next to the pit in controlled areas or backfilled progressively into the pit as part of rehabilitation. Topsoil would be stripped and stockpiled separately for rehabilitation. At closure, the surface topography would be similar to the pre-mining landscape. Progressive rehabilitation at Lake Maitland may include hauling waste from Centipede and Millipede to ensure land forms at mine closure at Lake Maitland resemble, as much as practicable, land forms that existed before mining.

It is proposed that tailings generated from the processing of ore mined at Lake Maitland would be stored in mined-out voids at the Millipede deposit. Due to the similar nature of the two deposits and also the consistent processing methodology, the tailings from the Lake Maitland and Millipede deposits would be of a very similar composition.

6.4 Soil and Waste Rock Management

Surface soil cover at each deposit would be stripped and stockpiled separately to be placed over the areas of backfilled pits as part of the ongoing rehabilitation. Non-mineralised overburden and waste rock would either be stockpiled next to the pit being mined or backfilled into suitable nearby mined-out areas. The waste rock arising from mining is oxidised and is therefore non-acid forming.

6.5 Dewatering

6.5.1 Millipede

Much of the uranium resource occurs at or below the water table and dewatering of the open pits would be required. The water table is typically between 0.5 m and 5 m below the natural ground surface. The water is contained within surficial sediments of the delta environment and is hypersaline.

To minimise the amount of water to be pumped from the pits during mine dewatering, water barriers would be constructed to reduce the ingress of water into mining areas during operations. Consistent with Condition of Approval 7.1 in Ministerial Statement No. 913 for mining at Centipede and Lake Way, Toro would design and implement a suitable groundwater barrier system around the mining areas at Millipede. Trials by Toro at the Centipede deposit have indicated that such barriers can significantly reduce groundwater inflow. Toro's modelling of the impacts of mine dewatering at Centipede also covered the Millipede mining area. Section 13 discusses groundwater impacts and actions that would be taken in the event that trigger levels for groundwater drawdown were exceeded.

There would be no discharge to surface water during routine operations as water from pit dewatering would be used as part of the process water supply. In the event that a significant rainfall event occurred during mining, there would be sufficient on-site storage capacity to retain incident rainfall until it could be used, evaporated or demonstrated to be of appropriate quality for controlled release to the environment. If accumulated surplus rainwater was within the range of natural water quality, approvals would be sought for discharge of surplus rainwater. Toro would only seek to discharge water in circumstances where the discharge water complied with criteria to ensure there was no adverse environmental impact.

6.5.2 Lake Maitland

There is a shallow groundwater table between 1 m and 3 m below the natural ground level and the uranium deposit generally occurs below the groundwater table. Pit dewatering would be required ahead of and during mining and would be undertaken in a manner similar to that proposed for the already assessed Centipede and Lake Way deposits (EPA Assessment 1819 and EPBC 2009/5174) and at Millipede. This would include the installation of barriers to minimise the amount of water to be pumped from the pits during mine dewatering.

There would be no discharge of mine water to surface water. During routine operations, as much water as possible from pit dewatering would be used as part of the operational water supply. For any excess water from pit dewatering, Toro has investigated the options of downstream aquifer reinjection and pumping to the processing plant adjacent to Millipede/Centipede. For the reinjection process, Toro has identified suitable aquifers into which the water could be returned and this is further discussed in Section 13.

In the event that a significant rainfall event occurred during mining, there would be sufficient on-site storage capacity to retain incident rainfall until it could be used, evaporated or demonstrated to be of appropriate quality for controlled release to the environment. If accumulated surplus rainwater was within the range of natural water quality, approvals would be sought for discharge of surplus rainwater. Toro would only seek to discharge water in circumstances where the discharge water complied with criteria to ensure there was no adverse environmental impact.

6.6 Water Requirements

The average annual water demand for the assessed Wiluna Uranium Project (EPA Assessment 1819 and EPBC 2009/5174) is estimated at up to 2.5 GL/a. This Proposal does not alter this annual requirement. The annual production capacity of the processing plant would not change from that already assessed (EPA Assessment 1819 and EPBC 2009/5174).

There are three main applications of water in the assessed Wiluna Uranium Project and this Proposal:

- Ore processing;
- Mining and haulage activities including dust suppression; and
- Accommodation and human consumption.

There are numerous available water resources in the Wiluna region. Most of the region's water supply is hypersaline water that has very limited practical use and is generally too salty to be economically and easily desalinated for human consumption or use in agricultural applications (irrigation and livestock). However, Toro has identified sufficient fresh to brackish and high salinity water to meet the Project's needs.

The water supply requirements of the assessed Wiluna Uranium Project (EPA Assessment 1819 and EPBC 2009/5174) and this Proposal can be met from a combination of:

- The proposed Lake Maitland borefield – fresh to brakish;
- Dewatering at Centipede and Millipede – high salinity;
- Lake Maitland dewatering – high salinity;
- Lake Way dewatering – high salinity; and
- West Creek borefield – fresh to brackish.

The Lake Maitland Project was acquired by Toro after the assessment process for the Wiluna Uranium Project was initiated. Toro's ground holding at Lake Maitland includes a source of fresh-brackish water 10 km to the north-east of the Lake Maitland deposit.

The results of pumping tests undertaken by Mega indicated that long-term pumping rates of up to 11.0 litres per second (L/s) may be achievable from production bores within the upper alluvial aquifer at Lake Maitland. Based on these results, a notional borefield layout for modelling purposes was designed comprising 10 pumping bores, with each bore pumping at between 3.3 L/s and 5.0 L/s, providing 1.4 GL/a.

Toro has undertaken further modelling of this borefield to assess its capacity to operate at 1.3 GL/a. for a period of 20 years. The modelling suggests this is possible, while maintaining a 75% aquifer saturation. Further discussion of this modelling is provided in Section 13.

The Lake Maitland borefield is a significant additional source of low salinity water for the processing plant at Millipede/Centipede approved under Ministerial Statement No. 913.

Based on engineering work to date, the assessed Wiluna Uranium Project and this Proposal require between 0.2 GL/a and 0.3 GL/a of low salinity water for human consumption and specific uses in the processing facility (e.g. for raising steam in boilers or for use in fire protection systems). The West Creek borefield is a source of fresh to brackish water. The EPA assessment for the original Wiluna Uranium Project concluded that operation of the West Creek borefield at a rate of up to 0.7 GL/a for seven years would not result in unacceptable environmental impacts. A section 5C licence application has been submitted to DoW for water abstraction from the West Creek borefield.

The identification of the Lake Maitland borefield provides greater flexibility to optimize water supply to the Project.

In addition, a significant amount of saline water is available from mine dewatering at Millipede and Lake Maitland. To help meet the water demand at the processing plant, Toro would connect the borefield and mining operation at Lake Maitland to the processing plant at Millipede/Centipede via an above ground pipeline laid within the corridor for the proposed haul road. The haul road corridor would be wide enough to accommodate the pipeline without the need for further disturbance of vegetation and fauna habitat.

To the extent that the Lake Maitland borefield and dewatering during mining activities at Lake Maitland yield surplus water, the borefield may be switched off or drawn upon at a reduced rate.

Further information about Project water requirements and how Toro proposes to manage potential impacts of its operations on surface water and groundwater is provided in Section 13.

6.7 Processing

Ore from Millipede and Lake Maitland would be trucked by haul roads to the already assessed plant for processing using a conventional alkaline agitated leach process (EPA Assessment 1819 and EPBC 2009/5174). The capacity of the processing plant would not increase from that already assessed, but it would operate for a longer period.

6.8 Finished Product Packaging and Transport

Finished product would be packaged at the processing plant in 205 litre (L) drums which would be weighed, labelled and given an identification number, then sealed, stacked and braced in sea containers. Up to five containers per month would be transported by road on the Goldfields Highway to Kalgoorlie and the Eyre Highway to South Australia for shipment from Port Adelaide or railed from there to Darwin Port for shipment. The rate of product transport and the method would not change from that already assessed (EPA Assessment 1819 and EPBC 2009/5174), but would occur over a longer period.

Product transport would be undertaken in accordance with the *Code of Practice for the Safe Transport of Radioactive Material* (ARPANSA, 2008) and applicable legislation.

The transport method selected was based on a study commissioned by Toro and Mega investigating all reasonable options including road/rail via Kalgoorlie to Port Adelaide and Darwin, as well as road-only into South Australia.

6.9 Supporting Infrastructure

Toro expects that the following ancillary infrastructure would be required to support mining.

6.9.1 Millipede

Haul roads and pipelines would be built to allow for the transport of ore and water to enable the mining of the ore body. Around the deposit, water storage facilities and evaporation ponds would be established (Figure 6.1). Due to the location of the Millipede deposit and its proximity to the Centipede deposit, no other supporting infrastructure would be required at Millipede. The construction and operational workforce employed at Millipede would be accommodated at the same village as the Centipede workforce.

6.9.2 Lake Maitland

The construction and operational workforce for Lake Maitland would be accommodated on site.

In effect Lake Maitland would be a small mine with support infrastructure, such as administration buildings, waste water treatment and vehicle servicing areas, camp accommodation and an above ground water pipeline to the processing plant at Millipede/Centipede. The scale of these buildings would reflect the nature of the operations and therefore would be on a smaller scale than previously proposed by Mega (EPA Assessment 1821). Toro expects that the maximum workforce based at Lake Maitland would be approximately 50 people, and that the operation would continue for approximately seven years, including closure.

6.10 Workforce

For its duration, including mining at Millipede and Lake Maitland, the Wiluna Uranium Project would employ about 200 personnel at full production capacity. A workforce of approximately 350 would be required during the construction phases at Millipede and Lake Maitland.

6.11 Radiation Management

Toro would adopt international standards as the basis for its radiation management system. The recommendations of the International Commission on Radiological Protection (ICRP) and the International Atomic Energy Agency (IAEA) have been adopted in Australia through state- and territory-based legislation or through the Australian Radiation Protection and Nuclear Safety Agency's (ARPANSA) series of radiation-related Codes of Practice.

While uranium is radioactive, potential hazards from its mining can be controlled through well-established design and management practices.

Radiation exposures to workers, contractors and members of the public as a result of mining at Millipede and Lake Maitland would be kept low and well within internationally accepted limits through key management strategies including:

- Adoption of the 'as low as reasonably achievable' principle (ALARA) in management of radiation doses for design and execution of the Proposal;
- Minimising dust from operations;
- Best practice control systems for processing, product packing and transport;
- Appointment of a Radiation Safety Officer; and
- Monitoring, Emergency Response and Security Plans

A comprehensive Radiation Management Plan (RMP), Radioactive Waste Management Plan (RWMP) and Transport Management Plan would be implemented.

The RMP and the RWMP would be developed in accordance with the *Radiation Safety Act 1975* and the *Mines, Safety and Inspection Regulations 1995*.

Toro has set a goal of maintaining doses from mining at Centipede and Lake Way at below 50% of the internationally accepted limit for workers and would also adopt this goal for mining at Millipede and Lake Maitland.

Potential radiation exposures to the public as a result of implementing the Proposal are assessed and described in Section 14. The assessment includes the identification of all potential sources, including ingestion pathways. Throughout the mine life and as a result of closure and rehabilitation, monitoring of radiation levels at key locations would ensure that Member of the Public doses are calculated and submitted to regulators. The dose estimation methods and dose conversion factors used would be those provided in relevant guidelines issued by the ICRP.

6.12 Waste Management

The main solid wastes arising from mining at Millipede and Lake Maitland would be:

- Non-mineralised overburden;
- Tailings from which uranium has been extracted; and
- General non-hazardous rubbish and sewage.

6.12.1 Tailings

Ore mined at Lake Maitland would be transported by truck for processing at the already assessed processing plant at Millipede/Centipede. The tailings produced from processing of this ore would be stored in the voids created from the mining of overburden, waste and ore at the Millipede deposit. Tailings would not be returned for storage at Lake Maitland.

Many mines (uranium and other commodities) use above ground structures to store tailings, which can give rise to dust, erosion, scouring and other issues, as well as result in a significant change to landforms.

The tailings management strategy for this Proposal has been developed by benchmarking against industry accepted leading tailings management practices. The strategy selected, to return tailings to mined-out pit voids to ensure their isolation and to prevent any adverse impacts to the environment and human health and safety, represents best practice tailings management. It also responds to the wishes of Traditional Owners of the land on which the Proposal would be undertaken that post-mining the area is returned to the natural landform. Accordingly, the Proposal will leave no artificial, above-ground tailings storage structures post-mining.

There is now considerable Australian and international experience with the adoption of in-pit tailings management. At the Ranger mine in the Northern Territory, 20 million cubic metres (Mm^3) of tailings have been deposited in-pit over a 12 year period. In-pit tailings storage is also undertaken at the Langer Heinrich mine of Paladin Energy Limited in the Namib Naukluft National Park, Namibia, which has been in production since 2007. Independent and internationally recognised uranium tailings experts conduct peer reviews of the design, construction and operations of the TSF at Langer Heinrich (Paladin Energy Limited, 2013).

In this Proposal, the containment of the tailings and the associated liquor and gases has been designed to meet environmental objectives that are discussed in Sections 13, 14 and 16. The environmental objectives that are directly applicable to management of tailings are as follows:

- To maintain the quality of groundwater and surface water, sediment and biota so that the environmental values, both ecological and social, are protected;
- To maintain the hydrological regimes of groundwater and surface water so that existing and potential uses, including ecosystem maintenance, are protected;
- To ensure that human health is not adversely affected; and
- To ensure that premises are decommissioned and rehabilitated in an ecologically sustainable manner.

To achieve the tailings management objectives, the following approach to tailings management at Millipede would be adopted:

- The overall area of disturbed footprint arising from mining activities and associated tailings storage would be minimised;
- A practical operating strategy would be implemented that takes cognisance of the mining schedule and the concomitant need for, and effects of, pit dewatering;
- The TSF would be developed in such a way that it maintains its integrity during operations and after mine closure, taking into account potential natural processes such as flood events;
- The TSF would be developed to produce an acceptable final landform and post-closure land use; and
- As much supernatant water as practicable would be recycled to the process plant to minimise water usage and the area required for evaporation facilities.

6.12.2 Other Waste

At Millipede, mineralised waste rock would be stockpiled until the tailings had consolidated sufficiently to be covered with waste material and rehabilitated. In this case, the low level mineralised material would be placed on the consolidated tailings and then covered with layers of non-mineralised material, followed by topsoil to complete rehabilitation. Rehabilitation would occur progressively throughout the mining operation. Excess waste, below ore grade, may be trucked to Lake Maitland to ensure that pit can be sufficiently backfilled to meet Toro’s conceptual closure plan to avoid any pit lakes remaining at Project closure.

At Lake Maitland, mineralised waste rock would be placed directly back into mined-out areas and covered with non-mineralised material. Rehabilitation of the mined areas would be progressive.

Domestic solid wastes at both Millipede and Lake Maitland would be recycled to the extent practicable. Non-recyclable materials would be disposed of in purpose-built landfills or at the shire landfill. Sewage would be treated by means of a proprietary treatment plant and disposed of in accordance with Shire of Wiluna and Western Australian Department of Health requirements.

Disposal would be consistent with Toro’s RWMP for the operational and decommissioning phases. This would be developed and submitted to the appropriate regulatory authorities.

6.13 Closure and Rehabilitation

Most of the land on which mining would occur at Millipede and Lake Maitland has native vegetation except for minor areas of existing disturbance associated with roads and access tracks and some cleared areas from previous mining trials.

Closure and rehabilitation at both Millipede and Lake Maitland would be carried out progressively, in the manner of a strip mining operation, with voids created by mining being backfilled using residue and overburden from active mine pits. This would be in addition to any operational footprint associated with the already approved activities at Centipede and Lake Way.

At cessation of all site activities, final landforming and revegetation would be completed in accordance with the approved Mine Closure and Rehabilitation Plan (MCRP).

A conceptual MCRP has been included as Appendix 3, and closure and rehabilitation at Millipede and Lake Maitland are discussed further in Section 16.

7 REGIONAL OVERVIEW

7.1 Regional Setting

The Millipede and Lake Maitland deposits are located in the Shire of Wiluna in the Murchison region of Western Australia's Mid West.

The town of Wiluna, located approximately 960 km north-east of Perth, is the principal centre in the shire. The town lies along the Goldfields Highway, which connects Wiluna to Leinster (population 1294, located 170 km to the south-south-east) and to Meekatharra (population 1377, located 130 km to the west). Wiluna Township is the gateway to the Canning Stock Route and the Gunbarrel Highway extends from Wiluna to Alice Springs. The nearest regional centre to Wiluna is Kalgoorlie (population just over 31,000, located 540 km south-south-east of Wiluna). At the last census (in 2011), the population of the Shire of Wiluna was 1159, of whom approximately 25% were Indigenous. The mining industry remains the largest employer in the shire, accounting for approximately 36% of all jobs (ABS, 2011). Local community interests have been strongly represented through the Wiluna Regional Partnership Agreement (WRPA). Regional partnership agreements are commitments by industry, government and local Indigenous communities and their representative organisations to work together to address locally identified priorities to achieve sustainable improvements for indigenous people living in a specific region. Toro has been an active participant in the WRPA which was established in 2009 and continued to function until mid-2015 through funding based on a Memorandum of Understanding on Indigenous Employment and Enterprise Development between the Australian Government and the Minerals Council of Australia.

The communities within the vicinity of the Millipede and Lake Maitland deposits face social and economic challenges common to many remote communities in Western Australia and elsewhere in Australia, ranging from high fluctuation in population to maintaining businesses and professionals and coordinating service delivery. Generally, the proportion of the local population with education levels to Year 12 or formal vocational or tertiary qualifications is lower than for the rest of Western Australia. About 25% of the Shire of Wiluna's population has completed Year 12 education or equivalent. Just over 6% are currently undertaking tertiary education, less than half the rate for the rest of Western Australia (ABS, 2011). Aspects of the human, social and cultural environment which affect or may be affected by this Proposal are further discussed in Section 19.

7.2 Cultural Heritage

7.2.1 Indigenous Culture

The township of Wiluna is located on Martu land. Martu are desert people and Traditional Owners and occupiers of land extending to the north and east of Wiluna from the edge of the Little Sandy Desert, east to the Gibson Desert and north into the Great Sandy Desert.

Martu lived the hunter-gatherer lifestyle in the western desert for thousands of years and today reside in communities on or near their country, including Wiluna, Jigalong and Parngurr.

People belonging to the Putitjarra, Manyjilyjarra, Kiyajarra and Kartujarra language groups of the Martu migrated to the Wiluna area during or after World War II as contact commenced with the exchange of labour and rations and continued following the establishment of the Seventh Day Adventist Mission in 1957 (Sackett, 1975–76; 1977; 1978). Some claim part-descent from the Putanytjarra, Tultarrawangka, Puralutjarra or Partu, the original groups of the Western Desert (Hingley and Kirby, 1980).

The Western Desert Cultural Bloc, as it is known in reference to the many land holding groups possessing strong similarities and adherence to 'the Law' across the Western Desert, extends in a broad sweep from Oodnadatta in far northern South Australia through the Great Victoria, Gibson and Great Sandy Deserts to the South Kimberley of Western Australia. The earliest occupation in the Western Desert Cultural Bloc is dated at 10,000 years before the present from a rock shelter near Warburton (Gould, 1977). There are also reliably dated rock shelters from the Little and Great Sandy Deserts up to 5000 years BP (Moore and Veth, 1988). Successful habitation in all regions of the Western Desert by 5000 years ago was attributed to a combination of the introduction of a new, efficient adze technology, the increasingly specialised use of seeds in diets and climatic change. Western Desert groups were highly mobile to cope with recurring droughts (Moore and Veth, 1988).

After European settlement, the early ethnographic research in frontier regions of the Western Desert was undertaken by Daisy Bates, Norman Tindale, and Ronald and Catherine Berndt. They found the region characterised by Aboriginal groups with close linguistic, social, cultural and traditional affiliations (Bates, 1985; Tindale, 1974; Berndt and Berndt, 1980). The ethnographic evidence suggests ‘a shared history, social and cultural inter-connectedness has resulted in genealogical relatedness which has often resulted in territorial connections through descent’ (de Gand, 2005). European settlement did not replace pre-existing Indigenous social structures:

> ‘A pattern of regular aggression and dispersal of Indigenous groups persisted. This is still the case today where Aboriginal people regularly come together for regional ceremonies, funerals and other social events. They gather resources widely and it is quite common that Aboriginal people shift their residence within a network of Western Desert communities’ (de Gand, 2007).

Wiluna occupies an important position in Aboriginal culture in the Western Desert region with Wiluna People retaining a strong commitment to traditional religious belief and ritual. It is traditionally a major Law centre and plays a central role at Law time with people travelling from as far away as Docker River in the Northern Territory to conduct rituals in and around Wiluna (Sackett, 1977).

The predominant dialect in Wiluna is Mandjildj, with Gadudjara, Budidjara, Bidjandjadjara, Giyadjara and Wanman also represented (Sackett, 1977).

Cultural sites in and around Wiluna tend to be predominantly associated with the Wati Kutjarra (Two Men) tradition (Tomkinson, 1974; Berndt and Berndt, 1977).

> ‘The Wati Kutjarra travelled southward along the Canning Stock Route following Karlaya Kutjarra (Two Emus) with whom they had important encounters near Meekatharra and at Tarlka, 43 km west of Wiluna. From Tarlka, Karlaya travelled south-east across Lake Way and into the desert while Wati Kutjarra journeyed north of Wiluna where they met the Kungkarungkaru (Seven Sisters) and continued their journey with them. During their travels across the desert, the Wati Kutjarra were involved in many encounters with other mythic beings. One of these encounters occurred near Lake Way where the Wati Kutjarra detoured from Uirrawula to kill and eat Papa (dingo). They had encounters with other ancestral beings in Wiluna including Warlawuru (Eaglehawk), Papanmaru (Goanna), Martuwa (Kangaroo Rat), Winpa (Lightning Snake) and Kinara (Moon)’ (Hingley and Kirby, 1980).

The resident Indigenous population in Wiluna has strong links to the Goldfields (Wongi) and Mid West (Yamatji) people. Regular contact occurs between people from Wiluna, the Punmu and Jigalong communities to the north and the Ngaanyatjarra communities to the east.

An important component of the maintenance of Aboriginal culture in the Wiluna region has been the establishment of the Tjukurba Art Gallery. In 2004, the formation of a new Shire of Wiluna Council prompted the development of a vision for a place to celebrate local art and history. A pilot Arts Encouragement Program was provided in Wiluna, Bondini, Kutkububba and Ululla followed by TAFE training to improve and broaden skills. This led to the establishment of the Tjukurba Gallery in the shire chambers as a place for Indigenous artists to paint and offer their works for sale, and as a display of historic photographs of Wiluna. The gallery takes its name from a widely recognised Martu word meaning story, dream time story or story of the lands.

The ethnographic research in the Western Desert undertaken by Bates, Tindale and the Berndts also covered the Barwidgee area in which Lake Maitland is located. Primary and secondary ethnographic and archaeological evidence indicates that Lake Maitland is within the ancestral areas of the Tjupan people. In 1908, Bates conducted fieldwork at Aboriginal camps near the towns of Sandstone, Laverton, Lancefield, Ida H Station, Malcolm, Menzies and Leonora. She referred to the region which includes Lake Maitland as the Central Areas Nation (Bates, 1985). Tindale conducted his research in the region in 1938–39 and again in 1966, travelling through Leonora, Laverton and Wiluna. He concluded that the region had a number of adjoining Aboriginal groups with considerable west and southward migratory activity leading to cultural, social and linguistic affiliations between them. According to Tindale, the linguistic group which traditionally inhabited the Barwidgee area was located 'west of Lakes Carnegie and Wells to Millrose and Barwidgee; at Erlistoun Creek and Lake Darlot, north to Wongawol and Princes Range' (Tindale, 1974).

The contact of the Berndts with the Aboriginal groups of the region occurred largely during two field surveys in 1957 and 1959 and confirmed economic, social and cultural interaction between groups belonging to the Western Desert Social and Cultural Bloc. According to the Berndts, the people who have more recently inhabited Barwidgee migrated there between the mid-1910s and the early 1920s (Berndt, 1959). This occurred through development of stations in the area during that period, with Aboriginal people from the Wiluna and Wongawol areas moving to Barwidgee to provide labour for the stations. Those who settled on the stations from the Western Desert Bloc incorporated fragments of earlier mythology and totemic geography in their own traditional framework (Macintyre et al., 1993). Following the adoption of the Pastoral Award for Aborigines in 1968, permanent residence and employment on stations reduced and movement to towns accelerated, including to Leonora, Wiluna, Meekatharra and Kalgoorlie. Aboriginal migration within the region was further consolidated with greater access to education, health and other services. Aboriginal people who moved from the stations to towns maintain contact with and continue to claim rights over cultural sites on the stations where they were born and often grew up (Shaw, 1991).

The principle mythology for the Barwidgee area is the Warlawaru (Eaglehawk) Dreaming. Sites connected with the story of the Warlawaru are at various locations from Mt Grey, Mindi Hill, Mt Joel and then north-west to Erawalla at Lake Way (Pitt, 2002).

7.2.2 Non-Indigenous Heritage

The first non-Aboriginal contact with the Wiluna region was made by the explorer John Forrest, during his expedition across Central Australia in 1874. Forrest began his expedition with six men and 20 horses from Geraldton. After reaching the watershed of the Murchison River, they continued east through the unknown desert centre of Australia, arriving in Adelaide eight months after their departure from Geraldton (http://adb.anu.edu.au/biography/forrest-sir-john-6211).

Forrest and his expedition were followed in the early 1890s by an exploring party from South Australia led by Lawrence Wells which reached the area near Lake Way before disbanding in early 1892. Four years later, the discovery of gold by three prospectors, George Woodley, James Wotton and Jimmy Lennon, led to a 'rush' and the birth of the town of Wiluna. Within months, there were more than 300 prospectors in the area who opened shallow underground and open pit workings. In 1897, a 460 ounce nugget was found in Wiluna, the largest uncovered in any of the Australian colonies to that time (Heydon, 1996).

The origin of the town name is uncertain. For a short time, it was known as 'Weeloona', thought to have been derived from either an Aboriginal word meaning 'place of winds' or the sound of the cry of curlew bird's native to the area.

The town thrived with continuing gold mining and the population reached more than 9000 by the early 1930s. Commercial scale production of arsenic also occurred at this time. At the height of this mining and mineral processing activity, Claude Albo de Bernales went to London to float the Wiluna Gold Corporation. As a result:

> 'the state government extended the railway from Meekatharra to Wiluna and the company had its own shining oil tanker on the waterfront at Geraldton and 12 railway tankers to haul oil 440 miles to its vast powerhouse at the mine' (Blainey, 1996).

The Northern Railway reached Wiluna in 1932 and operated until 1957. Wiluna was the furthest town from Perth reached by the narrow gauge system of the Western Australian Government Railways. At its peak, the town also had four hotels and many other amenities and facilities. As the Great Depression gripped in the 1930s, gold mining at Wiluna became a salvation for the jobless and men forced from the land:

> 'thousands of unemployed men and defeated farmers paid their fare or jumped the rattler to reach Wiluna and men and women who lived there in the 1930s seemed to believe there never was and never would be a town so vigorous and warm hearted' (Blainey, 1996).

To support the growing town population, the Wiluna Hospital was built in 1933 and continued until 1967 to operate from what are now the offices of the Shire of Wiluna. On its closure, a nursing post was established which developed into the Nganagganawili Aboriginal Health Service.

On 12 December 1937, Australia's 24th Governor-General, Major General Michael Jeffery, was born in Wiluna. He served as Governor-General between 2003 and 2008, the first Australian career soldier to do so. He had been Governor of Western Australia between 1993 and 2000.

The beginning of World War II had a severe impact on the gold mining industry and also on the population of Wiluna; many miners were called away to armed service. Immediately after the war, underground mining ceased in the area and the gold operations wound down to virtually nothing. By 1953, fewer than 400 people remained in the area and 10 years later this had dwindled further to about 90. The revival of the town began in the early 1980s with renewed gold mining.

In contrast to the ebbs and flows of mining activity, the pastoral industry in the region has continued to produce quality cattle and sheep.

To support the movement of stock in the early years of the Wiluna Township, Alfred Canning was commissioned in 1906 to survey and build a stock route from Wiluna to Halls Creek. The 1500 km route named after him took four years to complete. Wiluna is also a gateway to the Gunbarrel Highway, completed in 1958 as the first east-to-west road through the centre of Australia. Today it is a popular four-wheel drive route connecting Western Australia to Central Australia.

There are two sites of European heritage significance in the Wiluna region. The Mine Manager's House, 2 km south-east of Wiluna built in 1929, is a permanent entry on the Heritage Council of Western Australia's State Register of Heritage Places. Another permanent entry is the Wiluna District Hospital Group in Scotia Street, Wiluna, established over a period of about 30 years from the beginning of the 20th century.

There are no listed places on the State Register of Heritage Places in the vicinity of Lake Maitland.

7.3 Climate

The Proposal is located in the Mid West region of Western Australia. The Mid West has a semi-arid 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. Daily average temperatures range from 23°C to 38°C during summer and 5°C to 22°C during winter. The annual mean temperature is 28.7°C.

Rainfall is generally localised and unpredictable, and with the high temperatures there is significant annual evaporation, up to 3400 mm, exceeding rainfall in all months. The rainfall distribution is bimodal: from December to March rains result from tropical storms producing sporadic thunderstorms and from May to August extensive cold fronts move eastwards across Western Australia, reaching the Murchison and producing light rains (www.bom.gov.au – read on 1 June 2015). High rainfall events can cause flash flooding from sheet runoff. The mean number of days of rainfall equal to or greater than 1 mm is approximately 29 days per year. Median monthly rainfall varies from 1.5 mm in October to 18.7 mm in January (www.bom.gov.au – read on 1 June 2015). The rainfall data indicates that the longer duration, large rainfall events over periods of two to three days occur infrequently, predominantly as a result of the passage of remnant tropical cyclones across the north-west coast of Western Australia. In 1995, Cyclone Bobby resulted in a maximum daily rainfall of 125 mm at Wiluna and Wonganoo, about 40 km east of Lake Maitland. This was about 10 mm below the highest one-day rainfall total at either Wiluna or Wonganoo, recorded in 1945. A comparison between the years of maximum rainfall values and those of lower rainfall indicates daily falls of around 80 mm to 100 mm do not often occur concurrently at Wiluna and Wonganoo weather stations. This highlights the spatial variability in rainfall across the region. The magnitude of the individual large rainfall events is, however, comparable at both locations.

The nearest Bureau of Meteorology (BoM) station for which long-term and current rainfall data is available is Wiluna (Site No. 013012), 25 km to the north-west of the northern part of the study area for this Proposal and 100 km north-west of the southern part of the study area. The Wiluna station receives a mean annual rainfall of 226.6 mm with the majority of rain falling between January and March (www.bom.gov.au – read on 1 June 2015).

The prevailing wind directions are north-easterly (at 9 am) and south-easterly (at 3 pm). At night, south-easterly winds predominate. Calm wind conditions typically occur less than about 4% of the time. Toro has operated a local meteorological station near Wiluna since 2007. Good correlation exists between the meteorological monitoring, current BoM data and the data collected by Toro.

7.4 Geology and Hydrogeology

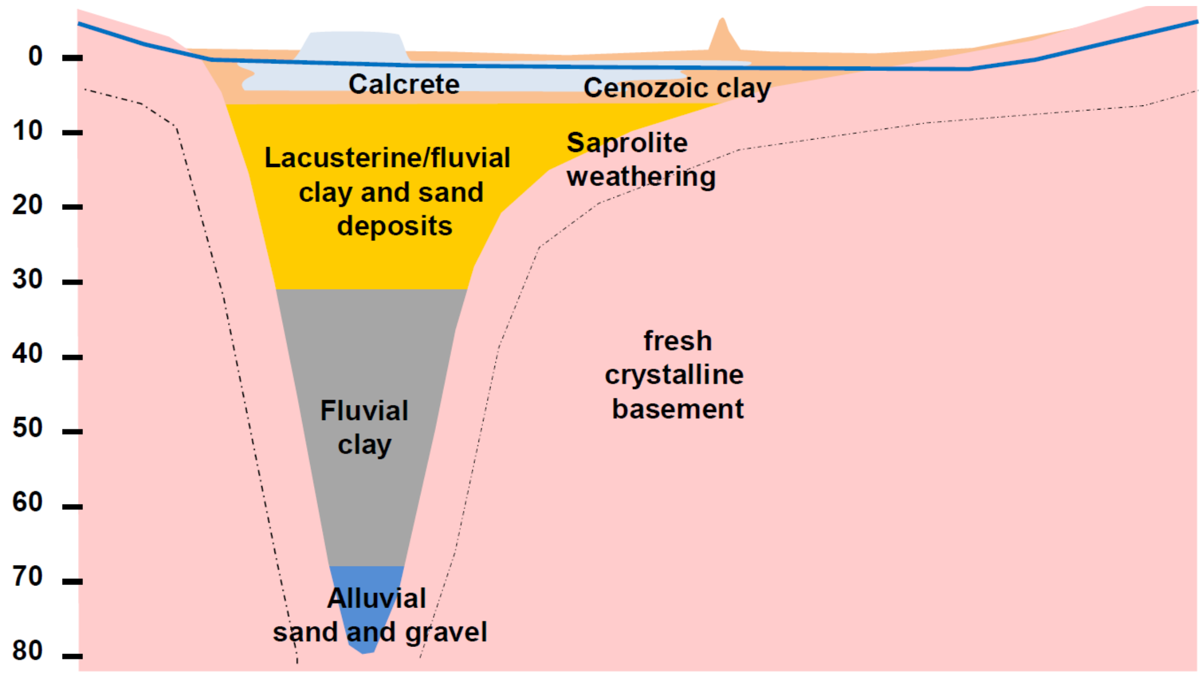
Regional geology comprises Archaean crystalline bedrocks dominated by granite cut through by the eastern margin of the Archaean Norseman-Wiluna greenstone belt. This belt is characterised by sedimentary and basic volcanic rocks. Granite and gneiss occur to the east, with Lake Way forming a central palaeodelta.

The palaeodrainage systems have filled with a sequence of sediments that reflect a reduction in energy over geological time. At its simplest, the sequence can be regarded as beginning with fluviatile sands, passing through low energy, lacustrine clay deposits and now subject to minor deposition of material eroded from the remnants of the catchment divides and the effects of wind, both erosion and deposition (Figure 7.1).

The basal sands are usually referred to as ‘palaeochannels’ or ‘palaeochannel aquifers’ to be distinguished from ‘palaeodrainages’, the latter term referring to the broad surface catchment systems. The palaeochannel sands in valleys that extend south-east to the Eucla Basin may be referred to as ‘trunk’ palaeochannels. In many places, there are ‘tributary’ palaeochannels, typically shallower and smaller in all dimensions than the trunk palaeochannels. The tributaries therefore lie in smaller catchments upstream from the main salt lakes which are significant hydrogeologically.

Shallow, surficial calcrete deposits occur at various locations in the palaeodrainage systems. These calcrete deposits have been subject to weathering and are in places karstic, the voids providing habitat for both stygofauna and troglofauna (Humphreys and Harvey, 2001). It is understood that the calcretes formed in former freshwater lakes. Many of them, such as the Millipede and Lake Maitland deposits, flank the current salt lakes. The implication is that the calcretes partly reflect the former size of the lakes prior to the development of the current arid and saline conditions.

Figure 7.1: Schematic cross-section through palaeochannel valley



The entire sedimentary sequence and the underlying and flanking, variably-weathered bedrock are all hydrogeologically relevant in the context of mining the Millipede and Lake Maitland deposits.

The entire sedimentary system is saturated to a level close to the bed elevation of the larger salt lakes. The surficial calcrete deposits and the deep 'palaeochannel' sands form long and continuous aquifers. Most of the intervening fine-grained sedimentary sequence is regarded as an aquitard, although there may be local zones of higher permeability sand lenses within it. The palaeovalley aquifers are recognised generally as having high groundwater storage capacity.

The bedrock, both weathered and fresh, forms a heterogeneous aquifer system, with the most permeable material commonly found in the transition zone between weathered and fresh rock. Groundwater elevations in the bedrock aquifers can be higher than those within the palaeochannel aquifers (i.e. there can be artesian conditions in the bedrock formations).

The palaeochannel aquifers are widely developed in the Yilgarn Craton for mineral processing water supplies. Small water supplies, relative to those provided by the palaeochannel wellfields, may be developed from bedrock, for example from cherty sediment packages and from fractured rock aquifers within the various igneous and volcanic rocks that form most of the basement material.

Near the playa lakes, palaeochannel aquifers are most likely recharged by very slow percolation of groundwater from the surficial aquifer via the lacustrine clays that underlie the uppermost sediments and local calcrete deposits near the playa surface. Some movement of groundwater from the bedrock into the alluvial sand and gravel of the palaeochannel aquifer also occurs where the bedrock contacts incised valley fill deposits.

Lacustrine clay is absent in the upper reaches of the palaeovalley tributaries so recharge can occur directly to the palaeochannel aquifer from the surficial aquifer, driven by rainfall infiltration and local runoff.

Direct recharge of the shallow calcrete aquifers would be expected to occur in response to rainfall events. Published data suggests that recharge directly from rainfall or via infiltration of runoff in areas of outcropping calcrete would constitute at least 1%, possibly as much as 5% of total annual rainfall. Rainfall events in excess of about 50mm are expected to generate sufficient runoff to infiltrate the calcrete via solution cavities (Johnson et al. 1999). Rockwater (1980) estimated rainfall recharge rates of 0.74 to 1.2% of Mean Annual Precipitation. Australian Groundwater Consulting (1986) found that localised recharge of the West Creek aquifer system is only likely to occur following significant runoff events and that historical records reveal several extended periods of five years or more without any significant runoff-producing rainfall events.

Some indirect recharge of the calcrete aquifer is also expected to take place via lateral inflow from the flanking alluvial sediments. Where groundwater is abstracted from production bores drilled into the calcrete aquifers, induced recharge would occur as a result of groundwater movement into the calcrete flowed from neighbouring less permeable sediments, into the calcrete.

Rainfall and runoff entering the shallow aquifers interact with the playa surfaces through capillary rise and evaporation from shallow sediments. Evapotranspiration would be expected to occur where groundwater levels are shallow, perhaps within 2 m to 3 m of the ground surface.

7.4.1 Millipede

Millipede is associated with the broad palaeochannel deltas that empty into the Lake Way hypersaline playa, which itself represents the remnants of a major primary palaeodrainage system of predominantly Tertiary age.

The uranium mineralisation is located in shallow deposits consisting of calcrete, dolomite, silt, clays and sand. These deposits were laid down within the palaeochannel drainage system and so follow the ancient channel structures. The present day drainage has eroded the existing channels resulting in a complex, discontinuous ore body. The mineralisation generally occurs at or in close proximity to the current water table, typically 1 m to 2 m below ground level. The total thickness of mineralisation does not typically exceed 6.5 m.

Uranium mineralisation at Millipede is dominated by carnotite ($K_2(UO)_2(VO_4)_2.1–3H_2O$), a potassium-uranium-vanadate mineral which has been precipitated out of solution and preserved within the lower reaches of tributary palaeochannels following subtle changes in groundwater chemistry and evaporation. The carnotite is found as coatings on bedding planes, in the interstices between sand and silt grains, in fissures within calcrete and dolomite, and in tubular voids in buried soil surfaces. The carnotite appears to have been precipitated onto any available surface.

7.4.2 Lake Maitland

Like Millipede, the Lake Maitland deposit is dominated by carnotite and hosted within a series of Tertiary age, clastic (sands, silts and clays), chemical (magnesium and calcium carbonates) and evaporitic (gypsiferous and saline muds) sedimentary units formed within a hypersaline playa lake setting. Locally, the sedimentary facies are variable and average total thickness is approximately 10 m.

The deposit is flat-lying and thin, averaging 1.7 m (range 0.02 m to 3.8 m) in thickness. The uranium generally occurs within a single coherent horizon located 2 m to 5 m below the surface of Lake Maitland. The mineralisation has a large areal extent, approximately 6 km long (north-south) and about 4 km wide (east-west). The deposit is essentially crescent-shaped with three arms extending towards the west.

7.5 Topography, Landforms and Soils

The Interim Biogeographic Regionalisation for Australia (IBRA) classifies the Australian continent into regions or bioregions of similar geology, landform, vegetation, fauna and climate characteristics. According to IBRA, version 7, Millipede and Lake Maitland lie within the Murchison Bioregion. The Murchison Bioregion is described as having low hills and mesas separated by flat colluvium and alluvial plains.

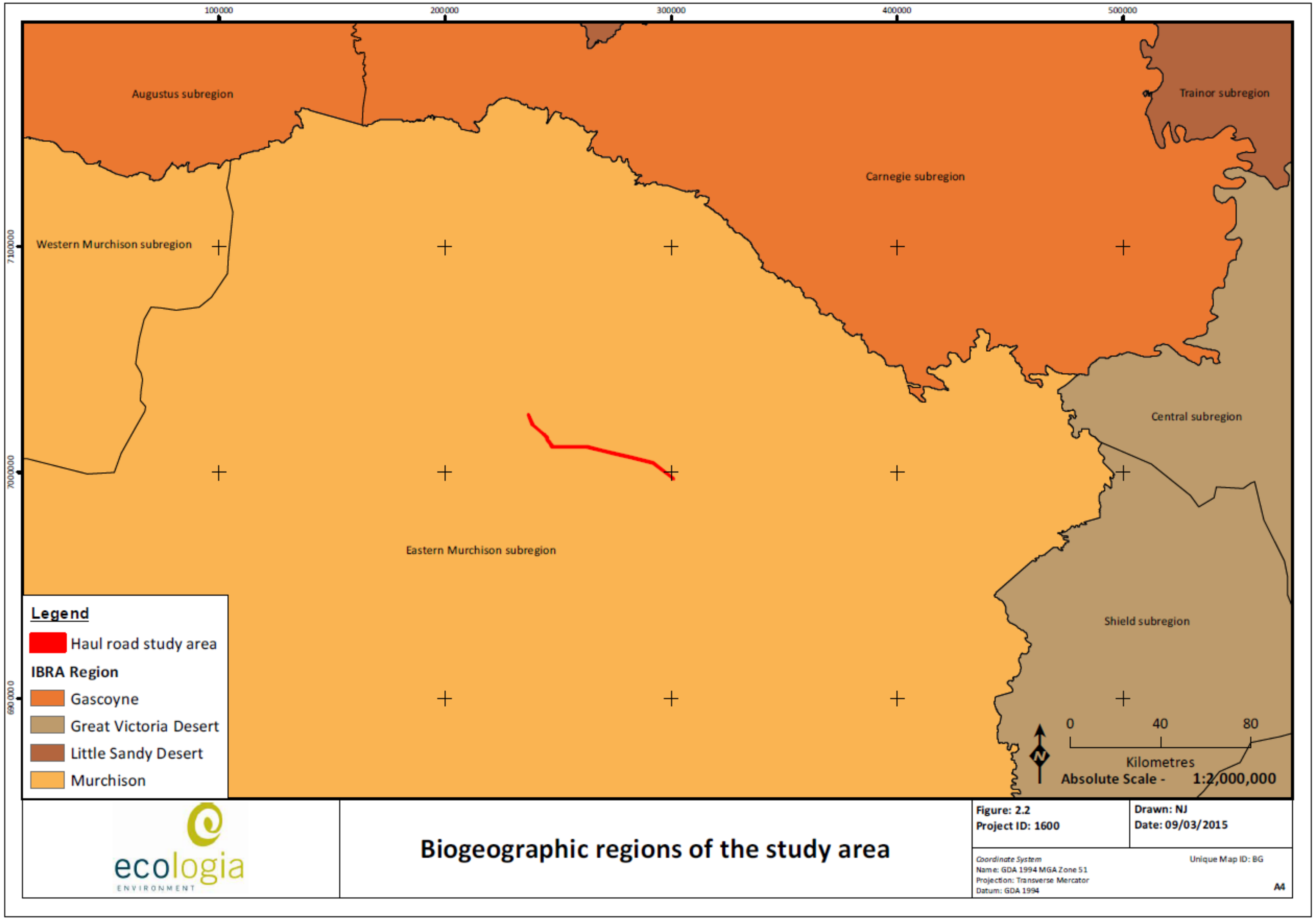
The Murchison Bioregion is further subdivided into the Eastern Murchison and Western Murchison subregions. This Proposal lies entirely within the Eastern Murchison subregion (Figure 7.2).

The Eastern Murchison subregion comprises the northern section of the Yilgarn Craton, encompassing the transitional zone between the eucalypt dominated environs of south-western Australia and the mulga/spinifex dominated areas of central Australia. In the East Murchison, extensive areas of red sand plains and breakaway complexes consist of minor dune development. Vegetation is dominated by mulga woodlands often rich in ephemerals, hummock grasslands, saltbush shrublands and *Tecticornia* (formerly *Halosarcia*) shrub lands. The subregion is characterised by its internal drainage, with salt lake systems associated with the occluded palaeodrainage system. Calcrete aquifers in the northern part of the subregion are known to support a wide range of subterranean aquatic fauna that are short range endemics. The subregional area for the Eastern Murchison is 7,847,996 ha (Cowan, 2001).

Land systems are defined as areas or groups of areas for which there are recurring patterns of topography, soil and vegetation (Curry et al., 1994). The land systems associated with this Proposal were mapped by Mabbutt (1963), for the Wiluna-Meekatharra area at the northern end of the study area, and by Pringle et al. (1994), for the north-eastern Goldfields area at the southern end of the study area.

The land systems relevant to this Proposal are further discussed in Section 9.

Figure 7.2: IBRA Subregions and study area



The Yilgarn Craton itself is a large area of Archaean age metamorphic rocks from which the uranium in the Millipede and Lake Maitland deposits is derived. The Craton is divided into a series of drainage systems that drain to the south-east. These systems now exhibit low relief, with subtle topographic divides separating the broad, flat valley floors. Prior to the deposition of the sedimentary sequence that filled the valleys, the topographic relief probably exceeded 100 m. Prior to the Tertiary period, during which the deepest sand deposits formed and were blanketed by lacustrine clays, the valleys had developed and presumably drained freely down-gradient to the south-east.

The Millipede and Lake Maitland deposits lie within the Carey Palaeovalley ephemeral drainage system which covers about 400,000 sq km of the Yilgarn Craton from Lake Way to the southern end of Lake Maitland. The Carey Palaeovalley drainage system, like many others in Western Australia, is the modern expression of a landscape that dates back tens of millions of years.

Lake Way is about 36 km long and up to 10 km wide, with a surface area of approximately 245 sq km. It receives surface flow from a surrounding 11,000 sq km drainage basin. Lake Maitland's catchment is about 4,300 sq km. It is one of the smaller lakes in the region. Both lakes are modern saline remnants of a previously freshwater system that has become saline in response to long-term (millions of years) drying of the Australian climate. Although their catchments are extensive, all but the largest rain events cause runoff that only drains locally.

The low location of the lakes in the landscape, partly reflecting the geological history of the region within which they are located, is fundamental to an understanding of how this affects the local and regional groundwater systems. These groundwater systems are, in turn, fundamentally important in operating the proposed mines and developing appropriate designs for subsequent closure of mining.

The dominant land use within the East Murchison subregion is native pasture grazing (85.5%). Other uses include: unallocated Crown Land and Crown Reserves (11.3%); mining, mostly gold and nickel (<2%); and conservation (<2%) (Cowan, 2001).

7.5.1 Millipede

The local topography comprises gently sloping sand plains, dunes and alluvial flats/playa type environments.

The Millipede deposit is located over two main land systems. The Carnegie Land System is the dominant one, encompassing the Lake Way salt lake and fringing saline alluvial plains and surrounding sand dunes. The other most common local land system, the Cunya, represents the calcrete earths and platforms adjacent to Lake Way. These support halophytic shrub lands and open mulga woodlands further from the lake's edge.

The majority of soils where mining would occur are loamy sands, clayey sands, sandy loams or sandy clay loams. Surface soils are generally relatively coarse in texture but show an increase in clay content with depth. The lake bed and fringe are characterised by finer textured soils.

The soils have a relatively wide range of pH and salinity with both of these attributes related to position in the landscape. In general, soils higher in the landscape are more alkaline and less saline, while those in flat areas at lower elevation are more saline and have neutral to acidic pHs. As would be expected, soils near or on the bed of Lake Way show high salinity and have neutral to alkaline pHs. None of the soils show pronounced hydrophobicity (water repellence), neither do they show a tendency to hard-setting.

Baseline testing of soils for trace elements (arsenic, cadmium, copper, lead, mercury, nickel, zinc) found no evidence of enrichment in these metals (Outback Ecology, 2008a – Appendix 10:21). The levels of total chromium identified within many of the samples were in excess of the values conventionally identified as potentially harmful to some agricultural plant species. However, the local native plant species may show quite different tolerance to chromium in soils. There was no clear evidence of higher levels of chromium in a particular location or soil type.

7.5.2 Lake Maitland

Locally, the topography is very flat with the ground surface of Lake Maitland (around 470 metres Australian Height Datum (mAHD) to 472 mAHD) grading from the north to south at a slope of less than 0.05% in the vicinity of the proposed mine. More regionally, the surface elevations increase to the east, west and north of the mine area at a grade of generally less than 0.2% to ground elevations along the catchment boundary of around 500 mAHD to 550 mAHD.

The landforms of the area are sand plains (with hardpan wash plains and some mesas, stony plains and salt lakes) on granitic rocks (and some greenstone) of the Yilgarn Craton. The area is relatively flat with little major gradient change over the area proposed for mining.

A baseline soil survey of Lake Maitland showed a significant degree of variation in soil profile morphology, both within and between the areas sampled (Outback Ecology, 2007b – Appendix 10:15). The greatest variations were between soils from contrasting positions within the landscape, namely spinifex, spinifex/*Acacia*, lake playa and calcrete associations.

A summary of the results is as follows:

- A significant degree of variation in soil profile morphology exists;
- A wide range of pH and salinity values occurs across the study area; as expected, the samples from the lake playa recorded the highest salinity levels;
- There are low levels of available soil nutrients (i.e. N, P, K and S);
- Total metal concentration was below detectable limits for As, Cd, Pb, Zn and Hg, with only Cr, Cu and Ni regularly above detectable limits;
- The physical soil attributes are variable, ranging from loamy sand to light medium clay with finer-textured soils present within the lake playa;
- Soil structure is variable, with little trend attributable to position within landscape or vegetation association;
- Many soil samples exhibited dispersive properties or the tendency to disperse following severe disturbance; this indicates that these materials may be readily mobilised once disturbed and redeposited; and
- The soil-water retention characteristics are variable, reflecting the variability in soil texture and particle grading.

7.6 Weather and Air Quality

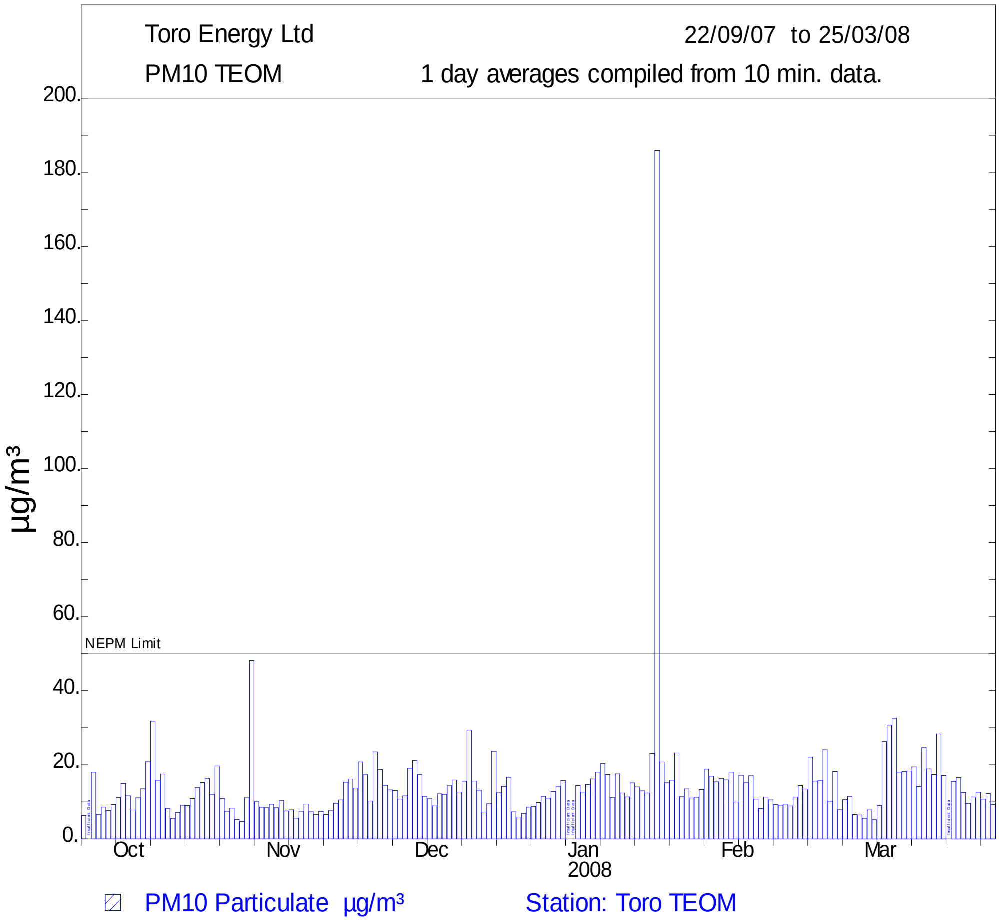
7.6.1 Millipede

The most recent detailed meteorological study at Lake Way was conducted for over a year. Hourly averages of 96.6% of data captured over this period showed that dominant wind directions were east to south-easterly. Temperature profiling was also evaluated as part of this study, which enabled mixing height modelling to be performed. These two factors dictate the dust and radiation dispersion potential and associated impacts from mining activities. Further meteorological monitoring carried out by Compliance Monitoring has shown good correlation between the historical monitoring, current BoM data and data collected by Compliance Monitoring on behalf of Toro.

A six-month campaign of air quality monitoring was carried out in 2007–2008 to evaluate ambient concentrations of airborne dust and deposited particulate matter (Compliance Monitoring, 2008). During the monitoring period, there was one exceedance of the National Environment Protection Measure (NEPM) value of 50 $\mu g/m^3$ (24-hour average) for fine particulate matter (PM_{10}). The event commenced around 1 am, peaked at 3 am and tapered off until about midday (Figure 7.3). The most likely cause of the observed high dust levels was an overnight dust storm or a bushfire, as the monitoring site is in a remote location, far removed from traffic, mining or other ground disturbing activity. No machinery was working in the area during the monitoring period.

Apart from this peak event, the second highest daily PM_{10} average was 48.2 µg/m^3. The overall daily average for PM_{10} over the six months monitoring was 14.6 µg/m^3. This value is comparable to (but somewhat lower than) the average summer PM_{10} values reported by the Western Australian Department of Environment and Conservation during a two-year study conducted in the Kalgoorlie region in 2006–2007 (DEC, 2009). Deposited dust levels recorded at Wiluna in 2007–2008 were also relatively low, averaging approximately 1.07 g/m^2/month of insoluble matter (Compliance Monitoring, 2008).

Figure 7.3: Air quality exceedance, January 2008



Baseline air quality assessment undertaken for Toro estimated typical background particulate concentrations for PM_{10} in the Millipede/Centipede project area at less than about 16 µg/m^3 and less than 32 µg/m^3 for total suspended particulates (Air Assessments, 2011).

7.6.2 Lake Maitland

Meteorological measurement equipment at the Leinster Aerodrome, about 90 km from the proposed mine site, indicates that the predominant wind directions at Lake Maitland are from the east and to a lesser extent, from the north and south. The annual average wind speed is 4.2 metres per second (m/s). Higher wind speeds (>5 m/s) are evenly distributed, reflecting the transient nature of a subtropical belt over the seasons. Wind directions in winter are predominantly northerly to easterly and in summer, easterly. Autumn and spring are transitional, with significant incidences in both directions. The seasonal influence of high winds is greatest in summer and lowest in winter. The incidents of light winds (<2 m/s) is greatest in autumn, followed by summer, with the least in winter. Industry in the vicinity of Lake Maitland has been focused on mining, with some diesel power generation at mining facilities and cattle stations. Fine particulate matter from combustion engines is not produced in great quantities.

The predominant source of particulate matter in the region is wind eroded crustal dust. Larger eroded dust particles tend to settle out, leaving finer particles of less than 10 micrometres (µm) to represent the majority of dust entrained in the atmosphere over long distances. Ambient concentrations of PM_{10} and TSP observed at Lake Maitland during baseline studies conducted over a nine month period in 2010 and 2011 were very similar to the background particulate concentrations estimated at Millipede: PM_{10} concentrations were typically less than 15 $\mu g/m^3$ and TSP concentrations were generally less than 30 $\mu g/m^3$.

7.7 Noise

Both Millipede and Lake Maitland are remote locations with a rural character and no nearby localised noise sources.

Mining at both locations would result in an increase in ambient noise and vibration due to the use of heavy and light machinery and the increased presence of people. Mining activities would be undertaken on a continuous 24 hour a day, seven days a week basis. Based on the findings of an environmental noise assessment carried out for Toro, the most significant sources of noise would be operation of surface miners and haul trucks (Lloyd George Acoustics, 2011). Noise modelling has shown that noise emissions from these activities would comply with the *Environmental Protection (Noise) Regulations 1997* at all noise sensitive premises.

It is possible that some disruption to fauna could occur as a result of noise from construction and mining activities. These effects are expected to be local in scale and not to have long-term detrimental impacts on fauna.

7.8 Traffic

Toro participated with Mega in a traffic analysis to assess the impacts of mining at Wiluna and Lake Maitland.

The analysis concluded that the construction and operational phases of mining at both locations would not have a significant impact on traffic flow in the region (Irving, 2010).

The traffic analysis showed that the increase in traffic as a result of construction, operation and finished product transport would not affect the current Level of Service (LoS) on the Goldfields Highway. The LoS is a ranking system associating traffic conditions from 'free-flow' (level A) to 'forced-flow' (level F – heavily congested) conditions along a given route. The Goldfields Highway between Kalgoorlie and Wiluna has a LoS C ranking, indicating a capacity of up to 1190 passenger car units per hour in both directions. Current traffic flows are well under half this level.

The finished product transport arrangements already assessed (EPA Assessment 1819 and EPBC 2009/5174) would also apply to product from mining at Millipede and Lake Maitland. The uranium oxide concentrate produced from ore mined at Lake Maitland would be processed at the already approved plant (EPA Assessment 1819 and EPBC 2009/5174) at Millipede/Centipede and transported from there.

All of the finished product would be transported in 205 L drums weighed, labelled and given an identification number and then sealed, stacked and braced in sealed sea containers on site for transport on the Goldfields and Eyre highways into South Australia for final shipment from Port Adelaide or Darwin Port. The rate of transport already assessed (up to five containers per month) would not change with mining at Millipede and Lake Maitland, but this would occur over a longer period.

An assessment of potential radiation exposures from finished product transport has shown that any exposures to members of the public would be well within Australian and international limits.

7.9 Conservation Estate

The nearest conservation reserve to both Millipede and Lake Maitland is the 53,248 ha Wanjarri Nature Reserve, located approximately 80 km to the south-east of Millipede and 40 km to the south-west of Lake Maitland. The reserve is a de-stocked pastoral lease surrounded by pastoral and mining activities. It is now classified as an A Class Reserve managed for its conservation, scientific and anthropological values and registered by the Australian Heritage Commission on the Register of the National Estate.

Approval was given in 1994 for the construction of a natural gas transmission pipeline running from north to south across the reserve.

Toro's activities would not affect the reserve, either directly or indirectly.

8 ASSESSING ENVIRONMENTAL IMPACT

This section describes the environmental assessment approach used for identifying and analysing potential impacts and the environmental significance of those impacts from the Extension to the Wiluna Uranium Project. Much of the information used in this process has been obtained from baseline studies, mine planning studies and feedback received during community and stakeholder consultation.

The approach considers how each key element of the Proposal may interact with the existing environment and result in an impact on one or more of the biophysical and socio-economic components of the environment. Development and implementation of mitigation and appropriate management strategies to prevent or limit potential impacts has considered best practice environmental management concepts and principles.

8.1 Key Environmental Factors

Environmental factors represent physical, biological, cultural, social and economic properties of the environment that are considered to be of ecological or social value (e.g. groundwater, surface water, flora, vegetation and fauna). At the stage of determining the assessment process for the Proposal as a PER, the EPA identified preliminary key environmental factors to focus preparation of the PER on the primary issues that were raised through environmental baseline studies and the views of communities, stakeholders and government agencies. Responses to the ESD provided further feedback on the environmental factors now assessed in this PER.

Environmental objectives are the desired goals that, if met, indicate that a proposal is not expected to have a significant adverse impact on the environmental factor. They are general statements about what is being protected for human generations (i.e. environmental objectives incorporate sustainability). For example, ensuring that human health is not adversely affected is the EPA objective for human health. To identify impacts, measurable endpoints are defined. The endpoints are expressions of changes to environmental objectives (e.g. changes to chemical concentrations, flow rates, habitat quantity and quality). For predicting impacts to human health, measurement endpoints would include concentrations of long-lived radioactive dust and radon. Impacts to long-term social, cultural and economic factors are predicted through analysis of measurement endpoints such as employment and income, education and training and land capability. Measurement endpoints also provide the primary basis for discussing the uncertainty of impacts on environmental factors and, consequently, are the key variables for study in monitoring and follow-up programs.

The overall 'determination of significance' of impacts on environmental factors is predicted by linking residual changes in measurement endpoints to impacts on the associated environmental objectives. For example, changes to habitat quantity and quality are used to assess the significance of impacts from the Proposal on the abundance and distribution of fauna populations, which influence their persistence. Impacts to fauna are then used to predict impacts on the accessibility and availability of fauna to future generations. Environmental factors, environmental objectives and measurement endpoints used in this PER are consistent with those identified in the ESD and are presented in Table 8.1.

Table 8.1: Environmental Objectives and Measurement Endpoints associated with Key Environmental Factors

Environmental Factor	Environmental Objective	Measurement Endpoints
Flora and Vegetation	To maintain representation, diversity, viability and ecological function at the species, population and community level.	• Plant community health (e.g. ecological risk assessment) • Relative abundance and distribution of plant species • Presence of invasive species • Plant community diversity
Terrestrial Fauna	To maintain representation, diversity, viability and ecological function at the species, population and assemblage level.	• Relative abundance and distribution of terrestrial fauna species • Terrestrial fauna health (e.g. injury/mortality of individual animals, ecological risk assessment) • Habitat quantity and fragmentation • Habitat quality • Sensory disturbance (noise)
Terrestrial Environmental Quality	To maintain the quality of land and soils so that the environment values, both ecological and social, are protected.	• Topsoil depth • Stockpile heights • Weed occurrence in Project area • Concentration of contaminants in soil • Soil physical properties: bulk density and water holding capacity • Erosion: presence of rills, gullies and sheetwash
Subterranean Fauna	To maintain representation, diversity, viability and ecological function at the species, population and assemblage level.	• Presence/absence of subterranean species • Diversity of subterranean species
Inland Waters Environmental Quality and Hydrological Processes	To maintain the quality of groundwater and surface water, sediment and biota so that the environmental values, both ecological and social, are protected. To maintain the hydrological regimes of groundwater and surface water so that existing and potential uses, including ecosystem maintenance, are protected.	• Physical analysis (e.g. pH, conductivity) • Major ions and nutrients • Total and dissolved metals • Flow rate and the spatial and temporal distribution of water
Human Health	To ensure that human health is not adversely affected.	• Total suspended particulates • Particulate matter (e.g. dust) • Long-lived radioactive dust • Radon • Radiation doses

Environmental Factor	Environmental Objective	Measurement Endpoints
Heritage	To ensure that historical and cultural associations, and natural heritage, are not adversely affected.	• Extent of disturbance of archaeological and cultural heritage sites
Rehabilitation and Decommissioning	To ensure that premises are decommissioned and rehabilitated in an ecologically sustainable manner.	• Local gamma radiation levels • Flora and vegetation community compositions • Fauna community compositions • Subterranean fauna community compositions
Offsets	To counterbalance any significant residual environmental impacts or uncertainty through the application of offsets.	• No residual impacts associated with the Proposal

8.2 Environmental Factors and Objectives

Sections 9–17 discusses relevant laws and regulations; the key environmental factors for the Proposal and how potential impacts on those factors have been assessed; the EPA's objective for each factor and how it would be affected by the Proposal; the environmental management proposed by Toro to ensure the EPA's objective is met; and the predicted outcome.

The EPA has identified the following key environmental factors for this Proposal:

- Flora and Vegetation – Section 9;
- Terrestrial Fauna – Section 10;
- Terrestrial Environmental Quality – Section 11;
- Subterranean Fauna – Section 12;
- Inland Waters Environmental Quality and Hydrological Processes – Section 13;
- Human Health – Section 14;
- Heritage – Section 15;
- Rehabilitation and Decommissioning – Section 16; and
- Offsets – Section 17.

The EPA required Toro to concisely describe and discuss the factors of Amenity (Noise) and Air Quality and Atmospheric Gases. This has been addressed in Section 18.

Each section has been prepared as a stand-alone assessment of the relevant environmental factor, drawing on reports from baseline studies and other extensive research and investigations which are referenced in the PER and attached to the PER as appendices or available from Toro on request.

Some of the reports from baseline studies and other technical documentation used in this assessment were commissioned by Mega, the former owner of Lake Maitland. Toro acquired the Lake Maitland project from Mega including all mining information, ie historical environmental reports and studies.Those studies and documentation were commissioned to assess a larger project at Lake Maitland than Toro now proposes (including a stand-alone processing plant), and consequently the environmental impacts would have been greater. Toro has commissioned a peer review of all of those studies and documentation to ensure they comply with current EPA policies and guidelines. Those peer reviews are reported in Appendices 10.37 (baseline aquatic), 10.38 (short range endemic invertebrate), 10.39 (subterranean fauna), 10.40 (vertebrate fauna), 10.41 (flora and vegetation), 10.42 (air quality), 10.43 background ambient air quality), 10.44 (ecological and human risk assessment), 10.45 hydrogeological and hydrological review), and 10.46 (sediment and erosion). Toro has also reconciled previous studies and documentation against its own Proposal and where necessary completed new studies for mining at Lake Maitland to ensure they remain relevant to the impacts to be assessed. Where Toro has referenced previous studies and documentation, it is because they are directly relevant to the proposed activities of Toro described in this assessment.

8.3 Spatial and Temporal Scales

8.3.1 Spatial Scales

Individuals, populations and communities function within the environment at different spatial (and temporal) scales. Impacts from a point source disturbance, such as a mining project on the biophysical environment, are typically more pronounced at the local scale (i.e. stronger near the mine or processing plant). Larger scale changes on the environment that occur further from the mine are more likely to result from other ecological factors and human activities. For example, impacts from the Extension to the Wiluna Uranium Project on environmental factors with limited movement, such as vegetation, will likely be confined to local changes caused by the Proposal. Some indirect changes to vegetation from dust deposition and air emissions may occur, but the impact also should be confined to the local scale of the Proposal.

Similarly, for species with small home ranges such as spiders, any impacts from the Proposal on a local breeding population will likely not be transferred to other populations in the region. Depending on the species, changes in the number of individuals within local populations over time are more related to local factors that influence reproduction and survival rates than the movement of individuals between populations. Accordingly, impacts from the Proposal on a local population are not expected to influence more distant populations in the region.

For environmental factors with more extensive distributions, such as migratory birds that can move within a region and terrestrial species with large home ranges, impacts from the Proposal have a higher likelihood of combining with impacts from other developments and activities. Catchments may be influenced by multiple users who generate cumulative impacts to these resources. Similarly, larger fauna species, such as kangaroos, that are influenced by the Proposal will likely encounter other human activities and developments in their daily ranges. Consequently, impacts from the Proposal could combine with influences from other developments in the individual's range.

The purpose of these examples is to emphasise the different levels of organisation in natural systems and the corresponding need to analyse and predict impacts of the Proposal on environmental factors at the appropriate spatial scales. For this PER, the spatial scope must be able to capture the scale-dependent processes and activities that influence the distribution and movement patterns specific to each environmental factor.

The spatial boundaries of study areas were designed to measure baseline environmental conditions and then predict impacts from the footprint and activities of the Proposal on the environmental factors (e.g. changes to ground and surface water quality, physical disturbance to vegetation). Local study areas were also defined to assess small-scale indirect impacts from Proposal activities on environmental factors, such as changes to vegetation and short-range endemic fauna.

The boundaries for regional study were designed to quantify baseline conditions at a scale that was large enough to assess the maximum predicted geographic extent of direct and indirect impacts from the Proposal on environmental factors. Proposal-related impacts at the regional scale include potential changes to groundwater quantity and quality for people who use these ecosystem services. Cumulative impacts are typically assessed at a regional spatial scale.

8.3.2 Temporal Scales

The approach used to determine the temporal scales (timeframe) of impacts from natural and human-related disturbances on environmental factors is similar to that used to define spatial scales. In this PER, temporal scales are linked to two concepts:

- The development phases of the Proposal (i.e. construction, operational and closure); and
- The predicted duration of impacts from the Proposal on an environmental factor, which may extend beyond closure.

Accordingly, the temporal scale for an environmental factor is defined as the amount of time between the start and end of a relevant Proposal activity (which is related to development phases), plus the duration required for the impact to be reversed.

8.4 Screening of Potential Impacts

The screening analysis identifies and assesses the linkages between Proposal components or activities, and the corresponding potential residual impacts to environmental factors (e.g. groundwater quantity, aquatic ecology and fauna). Potential pathways (mechanisms) through which the Proposal could affect environmental factors were identified from a number of sources including:

- A review of the Proposal configuration and scoping of potential impacts by the environmental and engineering teams and expert consultants for the Proposal;
- Scientific knowledge and experience with other uranium mines in Australia and elsewhere in the world;
- Consultation with communities and stakeholders; and
- Consideration of potential impacts identified from the ESD for the Proposal.

The first part of the analysis was to produce a list of all potential impact pathways for the Proposal. Each pathway was initially considered to have a valid linkage to potential impacts on an environmental factor. This step was followed by the development of mitigation that could be incorporated into the design of the Proposal to remove the impact or limit the impact to environmental factors. Mitigation included design elements, environmental principles and best practices, management policies and procedures, and social programs. Mitigation features were developed through an iterative process between the Proposal's engineering and environmental teams to avoid or mitigate impacts.

Knowledge of the mitigation was then applied to each of the pathways to determine the expected extent of Proposal-related changes to the environment and the associated residual impacts (i.e. impacts after mitigation) on environmental factors. Changes to the environment can alter physical measurement endpoints (e.g. groundwater chemistry and amount of habitat) and biological measurement endpoints such as fauna behaviour, movement and survival. For an impact to occur there has to be a source (Proposal component or activity) that results in a measurable environmental change (pathway) and a correspondent impact on an environmental factor.

Pathway analysis was a screening step used to verify the existence of primary linkages from the initial list of potential pathways for the Proposal. This screening step was largely qualitative, intended to focus the impact assessment on pathways requiring a more comprehensive consideration of impacts on environmental factors. Pathways were determined to be primary or secondary using scientific knowledge, logic and experience with similar developments and mitigation. Each potential pathway was assessed and described as follows:

- **Secondary**: Pathway is removed by mitigation so that the Proposal results in no detectable (measurable) environmental change or could result in a minor environmental change but would have a negligible residual impact on an environmental factor relative to baseline values; or

- **Primary**: Pathway is likely to result in a measurable environmental change that could contribute to residual impacts on an environmental factor relative to baseline or guideline values.

Primary pathways required further analysis and classification to determine the significance of the Proposal's impact on environmental factors. Pathways considered as secondary were not analysed further or assessed in the PER, because mitigation would remove the pathway or residual impacts to the environmental factors could be determined to be negligible through a simple qualitative evaluation of the pathway. Pathways considered secondary were not predicted to result in environmentally significant impacts on environmental factors.

8.5 Levels of Impact and Their Management and Mitigation

8.5.1 Project-specific impacts

In this PER the assessment of impacts considers all primary pathways likely to result in measurable environmental changes and residual impacts to environmental factors (i.e. after implementing mitigation). Residual changes to environmental factors are assessed using the measurement endpoints identified in Table 8.1.

Where possible and appropriate, the assessment has been quantitative to include data from field studies, modelling results, scientific literature, government publications, monitoring reports, and community and stakeholder consultation. Some assessments have been qualitative, incorporating professional judgement or experienced opinion.

Impacts to social, economic and cultural properties include positive and negative changes to employment, training and education, family income, traditional land use, family and community cohesion and long-term social, cultural and economic sustainability. A key aspect of the impacts analysis was to predict the influence of the Proposal on the development and sustainability of socio-economic conditions in the region.

8.5.2 Cumulative Impacts

Cumulative impacts are the successive, incremental and combined impacts of one or more activities on society, the economy and the environment (Franks et al, 2010). Cumulative impacts result when the effects of an action are added to or interact with other effects in a particular place and within a particular time. They are the total effects on a resource, ecosystem, human community or environmental value, taken in the context of all other activities affecting that resource or value (USEPA, 1999). Cumulative impact assessment aims to consider the effects of multiple actions or impacts on the environment (MCA, 2015).

Toro's assessment of cumulative impacts took into consideration both direct and indirect impacts of implementing the Wiluna Uranium Project, including its extension. 'Direct impacts' are taken to mean primary effects resulting from Project activities which are realised at the same time and place as the Project. 'Indirect impacts' are reasonably foreseeable secondary effects attributable to or induced by the Project, but which occur at a different time or place. For simplicity, Toro's analysis has taken direct impacts to include land disturbance and removal of habitat by excavation. In this analysis 'indirect impacts' includes impacts to environmental values induced by unintended physical changes resulting from Project activities such as impacts on vegetation arising from groundwater drawdown or dust deposition or increased herbivory resulting from increases in fauna populations near water storages created by the Project.

Direct impact areas considered in the cumulative impact assessment included the following features:

- Mine pits;
- Stockpiles and ROM pad areas;

- Access and haul roads;
- Pipelines and other linear infrastructure corridors; and
- Areas required for other associated mine infrastructure such as accommodation villages and workshops

The estimated total ground disturbance required for implementation of the Extension to the Wiluna Uranium Project is 1581.8 ha. The extent of clearing authorised under the approved Wiluna Uranium Project is 1530 ha.

The main sources of potential indirect environmental impacts associated with Toro's proposed mining activities are dust emissions (chiefly from wheel-generated dust along haul roads) and changes to groundwater systems as a result of mine dewatering and/or groundwater abstraction from borefields.

In order to provide a quantitative basis for evaluating possible indirect impacts from these sources, Toro has made the following assumptions:

- Areas within the predicted 0.5 m groundwater drawdown contour (that is, areas where the maximum groundwater drawdown could be 0.5 m or greater) were assumed to experience some level of indirect impact; and
- Areas within 25 m either side of mine haul roads were assumed to experience some level of impact on vegetation health as a result of increased dust deposition and other 'edge effects'.

The 0.5 m groundwater drawdown contour was selected on the basis that: i) it was the minimum level of change that could be reliably predicted and detected, and ii) it was judged that this level of change was small relative to the natural variability of groundwater levels and accordingly, was likely to be within a range of change that could be tolerated by local organisms without discernible adverse impacts.

The indirect impact area around haul roads was selected on the basis of published literature and Toro's own baseline dust deposition monitoring.

The most significant potential for combined or cumulative impacts from Toro's activities relates to biodiversity values: vegetation, threatened flora, fauna habitats and threatened fauna. The impacts of Project activities on, for example, air quality, noise or groundwater quality occur only at a very local scale and do not overlap with any other activities which exert a significant influence on local airsheds or aquifers. There is the potential for limited interaction in groundwater drawdown with other activities. However, as the impact of groundwater drawdown relates principally to groundwater ecosystems (and not, for example, to direct impacts on potable water supply), cumulative impacts on groundwater are discussed as an indirect impact on biodiversity. The estimated extent of groundwater drawdown used to consider the potential impacts of operating the West Creek borefield assessed water abstraction over a 25 year operational period and also assumed that the nearby Apex South borefield would be operated (by some unspecified third party) at the abstraction rate specified in the most recent groundwater licence issued for the borefield (2.36 GLpa). However, as discussed in section 13.7.2, Toro is not proposing the longer term use of West Creek and instead, would augment non-saline supply by drawing water from the proposed borefield to the north of Lake Maitland. The extent of groundwater drawdown effects shown in connection with mine dewatering adopts another very conservative assumption that the proposed low permeability barriers around mine pits are entirely ineffective.

Project-related direct and indirect impacts on biodiversity need to be understood in the context of other existing or foreseeable threatening processes. A threatening environmental process is one that decreases the resilience of ecosystems and populations. Examples of threatening processes include:

- Competition and habitat degradation by feral goats and other herbivores;
- Climate change;

- Invasion, establishment and spread of weeds;
- Land clearing for farming and other purposes;
- High frequency fire cycles; and
- Predation by feral cats, foxes and other predators

The assessment of cumulative impacts presented in the PER considers two types of cumulative impact:

- Cumulative impacts on specified environmental values of activities proposed under the extension to the Wiluna Uranium Project, taken in combination with activities already approved (EPA Assessment 1819 and EPBC 2009/5174); and
- Incremental impacts on particular environmental systems (for example, vegetation communities) of implementing the whole of the Wiluna Uranium Project (including its proposed extension), viewed in the context of the current condition of the systems.

Where information was available, the assessment considered predicted or potential impacts of Toro's activities in the context of the impacts associated with other proposals or threatening processes likely to have impacts on the same environmental values.

Further discussion of cumulative impacts on key environmental factors is provided in the PER as follows:

- Section 9 – Flora and Vegetation
- Section 10 – Fauna and Fauna habitats
- Section 12 – Subterranean Fauna
- Section 13 – Inland Waters Environemntal Quality and Hyrdological Processes (Pit Dewatering)

8.5.3 Determination of Significance

To determine whether an action is likely to have a significant impact on an environmental factor, it is necessary to take into account the magnitude, geographic extent, duration and frequency of the action and its impact. In addition, the degree of confidence with which the impacts of the action are known and understood must be considered.

The classification of residual impacts on primary pathways provides the foundation for determining the significance of the Proposal to environmental factors. Magnitude, geographic extent and duration are the principal criteria used to predict significance.

- **Magnitude**: Magnitude is a measure of the intensity of an impact or the degree of change caused by the Proposal relative to baseline conditions or a guideline value. It is classified into four scales. Magnitude can relate to percentage change (e.g. change from baseline) or to absolute changes that are above or below guidelines or thresholds.

- **Negligible**: No predicted detectable change from baseline values;
- **Low**: Effect is predicted to be within the range of baseline values or lower than guideline values;
- **Moderate**: Effect is predicted to be at or slightly exceeds the limits of baseline values or guideline values; or
- **High**: Effect is predicted to be beyond the upper or lower limit of baseline values or exceeds guideline values so that there is likely to be a change of state from baseline conditions.

- **Geographic Extent**: geographic extent refers to the area affected and is categorised into two scales: local and regional. Local-scale impacts mostly represent changes that are directly related to the Proposal's footprint and activities, but may also include small-scale indirect impacts. Changes at the regional scale are largely associated with indirect impacts from the Proposal, and represent the maximum predicted spatial extent of the impacts of the

Proposal. Regional-scale impacts may be influenced by cumulative effects from other developments.

- **Local**: Small-scale direct and indirect effects from the Proposal (i.e. within the Proposal footprint and lease area); or
- **Regional**: The predicted maximum spatial extent of combined direct and indirect effects from the Proposal that exceed local-scale effects (can include direct and indirect effects from the Proposal and other developments at the regional scale).

- **Duration**: Duration is the amount of time from the beginning of an impact to when the impact on an environmental factor is reversed, and is expressed relative to phases of the Proposal. Accordingly, duration is a function of the length of time that the environmental factor is exposed to Proposal activities or phases (e.g. construction, operational and closure), and reversibility.

- **Reversible**: Effect will not result in a permanent change of state of the population compared to similar environments not influenced by the Proposal; or
- **Irreversible**: Effect is not reversible (i.e. duration of effect is unknown or permanent).

After removal of the stressor on the environment, reversibility is the likelihood and time required for an environmental factor or system to return to a state that is similar to the state of systems of the same type, area and time that are not affected by the Proposal. Reversibility does not imply returning to environmental conditions prior to implementation of the Proposal. Ecological and socio-economic systems continually evolve through time. Subsequently, the physical, biological, social and economic properties of the social-ecological system at closure are likely to be different to the currently-observed patterns, independent of impacts of the Proposal. Return or recovery to pre-Proposal conditions may not be possible or even desirable. The state of ecological and socio-economic systems at closure of the Proposal may be equally functional with the desired structure, even if not the same as before development.

For those impacts that are reversible, the PER has evaluated the duration or time required to reverse the impact on the environmental factor or system. Some impacts are reversible soon after removal of the stressor, such as impacts to air quality from equipment operation. Other impacts may require a longer duration before changes are reversed.

In the PER, the determination of significance from impacts of the Proposal on the environmental factors was completed for each individual pathway. Then the overall significance of the Proposal on the environmental factor was assessed. For example, a pathway with a high magnitude, large geographic extent and long-term duration was given more weight in determining significance relative to pathways with smaller scale effects. The relative impact from each pathway is discussed with pathways predicted to have the greatest influence on changes to assessment endpoints contributing the most to the determination of environmental significance.

Environmental significance is used to identify predicted impacts that have sufficient magnitude, duration and geographic extent to cause fundamental changes to an environmental factor. Significance is determined by the risk to a value (e.g. a heritage value) or the persistence and function of populations (i.e. population level effects) within aquatic and terrestrial ecosystems, or the socio-economic system. The evaluation of significance uses principles of ecological sustainable development to the extent possible, but also involves professional judgement and experienced opinion.

The following definitions were used to determine the significance of impacts of the Proposal on aquatic, terrestrial and subterranean fauna incorporating the principles of ecological sustainable development as defined in the EP Act:

- **Not Significant**: Impacts are measurable at the individual level and are strong enough to be detectable at the population level, but are not likely to decrease the population resilience and increase the risk to population persistence; or
- **Significant**: Impacts are measurable at the population level and are likely to decrease the population resilience and increase the risk to population persistence. A number of high magnitude and irreversible impacts at the population level would be significant.

Definitions used for assessing the significance of impacts on socio-economics and on the protection of air quality, groundwater, surface water and sediments for aquatic and terrestrial ecosystems and human use are as follows:

- **Not Significant**: Impacts are measurable at the local scale and may be strong enough to be detectable at the regional scale, but are reversible; or
- **Significant**: Impacts are measurable at the regional scale and are irreversible. A number of high magnitude and irreversible impacts at the regional scale would be significant.

8.5.4 Uncertainty

Most assessments of impacts embody some degree of uncertainty. Confidence in impact assessment can be related to many elements including the following:

- Adequacy of baseline data for understanding existing conditions and future changes unrelated to the Proposal (e.g. extent of future developments, climate change, catastrophic events);
- Model inputs (e.g. estimates of the spatial distribution of salt concentrations in deep groundwater);
- Understanding of Proposal-related impacts on complex ecosystems that contain interactions across different scales of time and space (e.g. how and why the Project would influence fauna); and
- Knowledge of the effectiveness of the mitigation for reducing or removing impacts (e.g. environmental performance of the TSF).

Uncertainty in such elements could result in uncertainty in the prediction of environmental significance. Methods applied in this PER to reduce or eliminate uncertainty have included:

- Using the results from several models and analyses to help reduce bias and increase the precision of predictions;
- Implementing a conservative approach when information is limited, so that impacts are typically overestimated; and
- Additional mitigation.

8.5.5 Management, Monitoring and Follow-up

In this PER, monitoring programs are proposed to deal with uncertainties associated with the impact predictions and mitigation. In general, monitoring is used to test and verify impact predictions and determine the effectiveness of mitigation. Monitoring is also used to identify unanticipated effects and implement adaptive management. Typically, proposed monitoring includes one or more of the following categories:

- **Compliance Inspection**: Monitoring the activities, procedures and programs undertaken to confirm the implementation of approved design standards, mitigation and conditions of approval and company commitments;
- **Environmental Monitoring**: Monitoring to track conditions or issues during the mine and plant life and implementation of adaptive management; and

- **Follow-up**: Programs designed to test the accuracy of impact predictions, reduce uncertainty, determine the effectiveness of mitigation and provide appropriate feedback to operational management for adopting new mitigation designs, policies and practices.

These monitoring programs form part of the environmental management system for the Wiluna Uranium Project, including its extension. If monitoring or follow-up detect impacts different to those predicted or highlight the need for improved or modified mitigation, adaptive management would be implemented in consultation with regulatory authorities. This could include increased monitoring, changes in monitoring plans or additional mitigation.

9 FLORA AND VEGETATION

9.1 Objective

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

9.2 Relevant Legislation and Policy

9.2.1 *Wildlife Conservation Act 1950*

All native plants in Western Australia are protected under the *Wildlife Conservation Act 1950* (the Act). Any activity which involves the taking of part or the whole of a plant may require a licence or permit to do so. Flora that is relatively unknown, is under threat or has only a small known area of distribution is afforded special protection under the Act, and the following categories of conservation may be applied:

- T: Threatened Flora. Declared Rare Flora (DRF - Extant) under schedule 1 of the Act. Taxa that have been adequately surveyed 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.
- X: Presumed Extinct Flora (DRF - Extinct) under schedule 2 of the Act. Taxa that have been adequately surveyed and there is no reasonable doubt that the last of the species has died and has been gazetted as such.

The taking of threatened flora may not occur without the permission of the Minister for Environment.

The Department of Parks and Wildlife (DPaW) also produces a list of Priority Species and Ecological Communities under the Act. Priority Flora Taxa are as follows:

- Priority One: Poorly known taxa. Taxa that are known from one of a few collection records (generally less than five), all on lands not managed for conservation and under threat of habitat destruction and degradation. Taxa may be included if they are comparatively well known from one or more localities, but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes.
- Priority Two: Poorly known taxa. Taxa that are known from one of a few collections, some of which are on lands not under threat of habitat destruction or degradation (e.g. national parks, conservation parks, water reserves). Taxa may be included if they are comparatively well known from one or more localities, but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes.
- Priority Three: Poorly known taxa. Taxa that are known from collections or sight records from several localities not under imminent threat, or from several widespread localities with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Taxa may be included if they are relatively well known from several localities, but do not meet adequacy of survey requirements and known threatening processes exist that could affect them.
- Priority Four: Rare, Near Threatened and other taxa in need of monitoring:

- Rare: Rare taxa are taxa that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of species protection, but could be if present circumstances change. These taxa are usually represented on conservation lands.
- Near Threatened: Taxa that are considered to have been adequately surveyed and that do not qualify for conservation dependent, but are close to qualifying for vulnerable.

- Taxa that have been removed from the list of threatened species during the last five years for reasons other than taxonomy.

- Priority Five: Conservation Dependent Taxa. Taxa that are not threatened, but are subject to a specific conservation program, the cessation of which would result in the taxa becoming threatened within five years.

Project proponents wishing to disturb Priority Flora should first consult with DPaW regarding the impact of a proposal on the species' conservation status.

DPaW has been identifying and informally listing threatened ecological communities (TECs) since 1994. As of May 2014, 376 TECs had been endorsed by the Minister for Environment. The only TEC occurring in the Murchison Bioregion is the Depot Springs Stygofauna Community which would not be impacted by this Proposal.

Where there is insufficient information available to classify a community as threatened, or where a community is rare but not currently threatened, it is placed on the priority list and referred to as a priority ecological community (PEC). A list of PECs may be found on the DPaW website (http://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/wa-s-threatened-ecological-communities). At November 2014, there were 309 listed PECs. Of these, 11 PECs are within 50 km of where the Project would be implemented. Refer to Figure 9.5.

9.2.2 EPA Policies

The EPA has produced Position Statement No. 2 for the environmental protection of native vegetation in Western Australia (EPA, 2000). This statement outlines the EPA's position on clearing in agricultural areas and other areas of the state. It also outlines the elements the EPA will take into consideration when assessing a proposal. Proponents are required to demonstrate that all reasonable measures have been undertaken to avoid impacts on biodiversity. Where some impact on biodiversity cannot be avoided, it is for the proponent to demonstrate that the impact will not result in unacceptable loss.

EPA Position Statement No. 3 outlines the use of biological surveys as an element of biodiversity protection in Western Australia (EPA, 2002). Proponents are expected to undertake field surveys that meet the standards, requirements and protocols as determined and published by the EPA. Based on the guidance provided in this statement, Toro has undertaken Level 2 biological surveys and desktop assessments building on previous surveys to assess the impacts of the Proposal. All surveys carried out which form part of this assessment are compliant with the requirements of Position Statement No. 3. Further information about the requirements for flora and vegetation surveys is provided in EPA Guidance Statement No. 51 (EPA, 2004a). All surveys were compliant with the requirements of this guideline, except in cases where the EPA expressly asked for a deviation from the guideline. This occurred during the survey of *Tecticornia* at both Lake Way and Lake Maitland, where the EPA asked that the recommendations of a peer review of previous survey efforts be implemented (Actis, 2012 – Appendix 10.61).

9.2.3 Environmental Protection and Biodiversity Conservation Act 1999

The EPBC Act (Cwlth) provides protection for nationally and internationally threatened plants and ecological communities. The EPBC Act provides for the identification and listing of threatened species, development of a register of critical habitats, recognition of key threatening processes and, where appropriate, reducing the impacts of these processes through threat abatement plans.

Under the EPBC Act, listed threatened species are given one of the following classifications:

- Critically Endangered: A taxon is Critically Endangered when it is considered to be facing an extremely high risk of extinction in the wild;

- Endangered: A taxon is Endangered when it is considered to be facing a very high risk of extinction in the wild;
- Vulnerable: A taxon is Vulnerable when it is considered to be facing a high risk of extinction in the wild; and
- Conservation Dependent: A taxon is Conservation Dependent if the species is the focus of a specific conservation program, the cessation of which would result in the species becoming vulnerable.

Under the EPBC Act, the federal Minister for the Environment is able to provide species protection to ecological communities of national importance that are subject to processes that threaten to destroy or significantly modify such communities. The Commonwealth list of TECs under the EPBC Act can differ from that of a state. None of the TECs listed by Western Australia's DPaW are included on the Commonwealth TEC list, and the Commonwealth has not identified any TECs on land where this Proposal would be undertaken.

9.3 Proponent Studies and Investigations

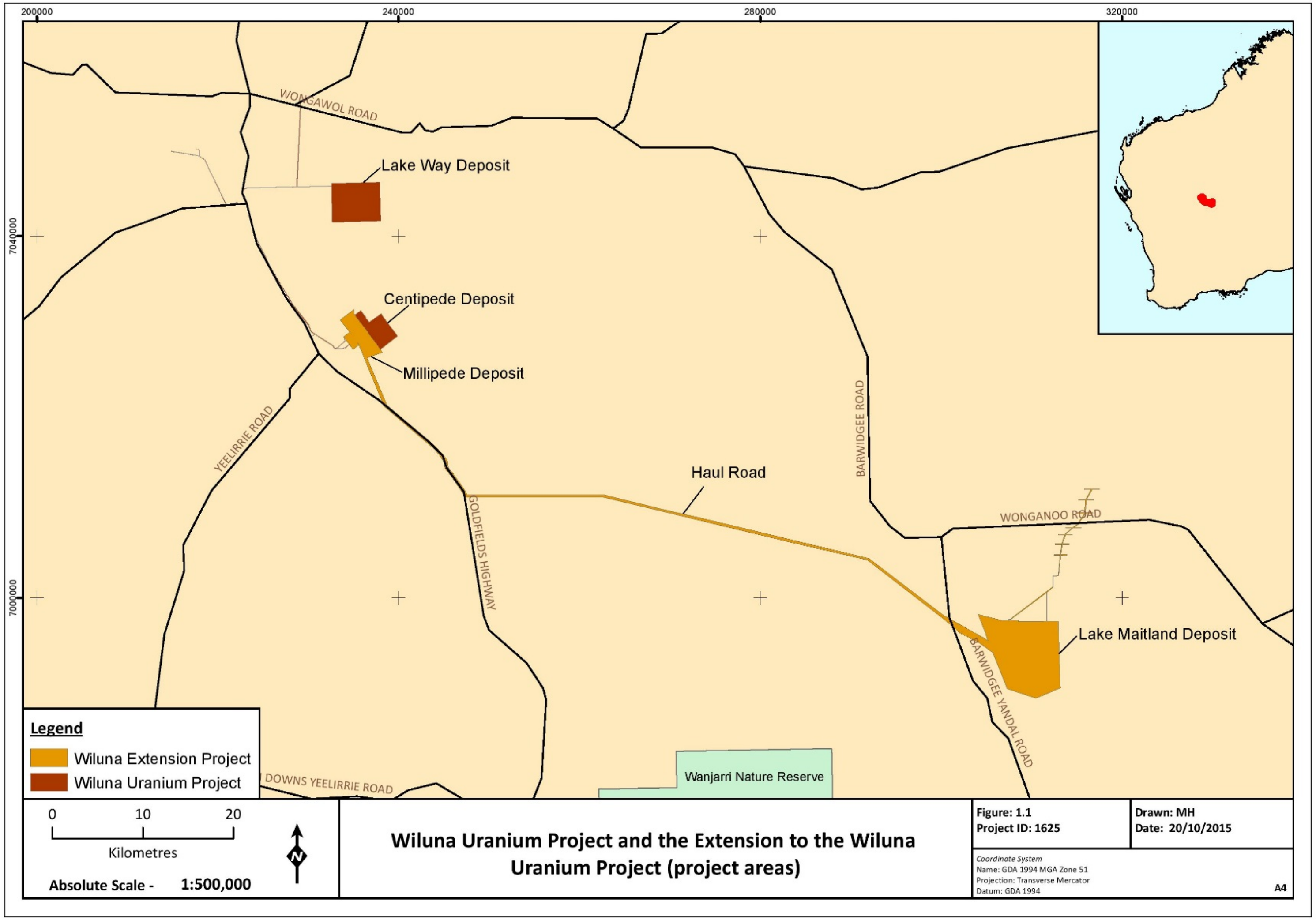
To inform this assessment, Toro was asked to provide a synthesis of the multiple flora and vegetation surveys, studies and taxonomic identifications conducted for the Wiluna Uranium Project, including its extension. The synthesis is summarised below and in Table 9.1. The areas covered by the surveys, studies and taxonomic identifications are shown in Figure 9.1. The full synthesis is in Ecologia 2015g – Appendix 10.49

Table 9.1: Summary of flora and vegetation assessments conducted for the Wiluna Uranium Project, including its Extension

Reference	Report	Timing	Quadrats (size)	Taxa (Genera/ Families)	Significant Flora	Veg Units	Significant Vegetation	Significance	Introduced Flora
Outback Ecology (2007a - Appendix 10.58)	Lake Way and Centipede flora and vegetation	Oct 2007	108 (30x30m)	132 (65/32)	None reported	22	Me1 Halophytic vegetation	Restricted Distribution Restricted, New species	**Lysimachia arvensis* (as **Anagallis arvensis*)
Outback Ecology (2009b - Appendix 10.17)	Lake Maitland flora and vegetation	May 2007 Nov 2007 May 2009	91 (30x30m)	244 (78/36)	*Maireana ?prosthecochaeta* (P3) 5 range extensions	31	KRE	Restricted Distribution	**Tribulus terrestris* **Portulaca oleracea*
Outback Ecology (2010f – Appendix 10.20)	Lake Maitland flora and vegetation	Jan/Feb 2010	160 (30x30m)	256 (83/39)	None reported	40	Kopi Ridge	Local	*Portulaca oleracea* *Tribulus terrestris*
Niche (2011a - Appendix 10.12)	Lake Way, Centipede and West Creek Borefield flora and vegetation	Apr/Jun 10 Sep/Oct 10	264 (30x30m)	428 (161/57)	*Eremophila congesta* (P1) *Tecticornia* sp. Lake Way (P1) *Eremophila arachnoides* subsp. *arachnoides* (P3) *Stackhousia clementii* (P3) *Homalocalyx echinulatus* (P3) *Mirbelia stipitata* (P3) 24 range extensions and 4 atypical variants	34	BIF Ca1 Ca2 Cr Fr1 Sh complex Sl1	Priority flora Priority flora Priority flora Restricted At risk Priority flora	**Acetosa vesicaria* **Brassica tournefortii* **Centaurea melitensis* **Sonchus oleraceus*
Actis (2012 - Appendix 10.61)	*Tecticornia* review	As for Niche (2011a - Appendix 10.12)			*Tecticornia* sp. Lake Way (P1) *Tecticornia cymbiformis* (P3) 5 potentially undescribed *Tecticornia* taxa	-	Fr1 Sl1 Cp2	Potential GDE Potential GDE Potential GDE	-
Niche (2014 - Appendix 10.13)	Millipede flora and vegetation	Apr/Jun 10 Sep/Oct 10 Oct 2013	30 (30x30m)	185 (100/40)	Eremophila arachnoides subsp. arachnoides (P3) Stackhousia clementii (P3)	10	Ca1 Tecticornia vegetation	Priority flora Restricted, Sig. Flora	None reported

Reference	Report	Timing	Quadrats (size)	Taxa (Genera/ Families)	Significant Flora	Veg Units	Significant Vegetation	Significance	Introduced Flora
Ecologia (2015a - Appendix 10.36)	Millipede to Lake Maitland Haul Road flora and vegetation	Jun 2014 Oct 2014 Jan 2015 Mar 2015	130 (30x30m)	223 (93/34)	Cratystylis centralis (P3) Stackhousia clementii (P3) Tecticornia *cymbiformis* (P3) Eremophila pungens (P4) Frankenia confusa (P4) 5 range extensions & 2 atypical variants	12	S/V (Tecticornia community)	Restricted Distribution Restricted Distribution	**Bidens* bipinnata *Citrullus ?lanatus *Tribulus terrestris
Ecologia (2015e - Appendix 10.7)	Lake Way and Lake Maitland *Tecticornia*	Nov 2014 Jan 2015	162 (3x3m) along 15 transects	65 (27/11)	*Tecticornia* sp. Lake Way (P1) *Tecticornia* sp. Sunshine Lake (P1) *Tecticornia cymbiformis* (P3) 7 potentially new *Tecticornia* taxa	9	All *Tecticornia* communities	Restricted, Sig. Flora, Unknown	None reported

Figure 9.1: Survey areas for the Wiluna Uranium Project and its Extension



9.3.1 Lake Way and Centipede (Outback Ecology 2007a - Appendix 10.58)

A Level 2 flora and a vegetation assessment was undertaken in October 2007 for the Lake Way and Centipede deposits as part of the Toro Wiluna Uranium Project (Outback Ecology 2007a - Appendix 10.58). The survey included 108 quadrats (each 30 x 30 m) and sampled 132 vascular flora taxa with no significant flora reported (Table 9.1). The introduced **Lysimachia arvensis* was recorded (as **Anagallis arvensis*) from one location at the Lake Way deposit. A total of 22 vegetation units were described, including significant vegetation units: Me1 (*Melaleuca xerophila* mid density low forest) which is generally restricted to a narrow band along the lake edge; and nine halophytic vegetation units which were considered significant due to unique community assemblages.

9.3.2 Lake Maitland (Outback Ecology 2009b - Appendix 10.17)

A Level 2 flora and a vegetation assessment was undertaken in May 2007, November 2007 and May 2009 for the Mega Uranium Lake Maitland project (Outback Ecology 2009b - Appendix 10.17). The survey included 91 quadrats (each 30 x 30 m) and sampled 244 vascular flora taxa with one potential Priority 3 flora taxon (*Maireana ?prosthecochaeta*) and five range extensions (*Acacia aneura* var. cf. *major*, *Acacia brumalis*, *Acacia maxwellii*, *Acacia scleroclada* and *Sida kingii*). The introduced **Tribulus terrestris* was recorded from one location at Lake Maitland. A total of 31 vegetation units were described, including significant vegetation unit KRE (Low woodland of *Eucalyptus striaticalyx* and *Grevillea sarissa* subsp*. bicolor* over low scrub of *Lawrencia helmsii*, *Sclerolaena fimbriolata* and *Tecticornia* aff*. undulata.*) which is restricted to several areas to the south of Lake Maitland (Table 9.1).

9.3.3 Lake Way, Centipede and West Creek Borefield (Niche 2011a - Appendix 10.12)

A Level 2 flora and a vegetation assessment was undertaken in April 2010, June 2010 and September/October 2010 for Lake Way, Centipede and West Creek Borefield deposits as part of the Toro Wiluna Uranium Project (Niche 2011a - Appendix 10.12). The survey included 264 (30 x 30 m) quadrats (including resampling of the Lake Way and Centipede quadrats from the Outback Ecology (2007a) survey) and sampled 428 vascular flora taxa, including six Priority flora taxa (two Priority 1 taxa: *Eremophila congesta* and *Tecticornia* sp. Lake Way, and four Priority 3 taxa: *Eremophila arachnoides* subsp*. arachnoides*, *Stackhousia clementii*, *Homalocalyx echinulatus* and *Mirbelia stipitata*), 24 range extensions (*Brachyscome iberidifolia*, **Centaurea melitensis*, *Cratystylis subspinescens*, *Cynanchum floribundum*, *Dicrastylis doranii*, *Disphyma crassifolium* subsp*. clavellatum*, *Dysphania truncata*, *Euphorbia biconvexa*, *Frankenia interioris*, *Frankenia* sp. cf. *glomerata*, *Gnephosis angianthoides*, ?*Gompholobium simplicifolium* (as ?*Otion simplicifolium*), *Gunniopsis rodwayi*, *Gunniopsis septifraga*, *Isoetopsis graminifolia, Maireana amoena*, *Maireana appressa*, *Murchisonia volubilis*, *Nicotiana rotundifolia*, *Polygala isingii*, *Ptilotus murrayi*, *Scaevola tomentosa*, *Senna manicula*, and *Trachymene ceratocarpa*) and four atypical variants (*Frankenia ?interioris* and *Frankenia* sp. cf. *glomerata*, which are also listed above as range extensions, and *Scaevola spinescens* and *Rhagodia drummondii*). In addition, four introduced flora species (**Acetosa vesicaria*, **Brassica tournefortii*, **Centaurea melitensis* and **Sonchus oleraceus*) were recorded.

A total of 34 vegetation units were identified, of which seven were described as potentially significant.

9.3.4 *Tecticornia* Review (Actis 2012 - Appendix 10.61)

The *Tecticornia* specimens collected during the surveys supporting the Lake Way, Centipede and West Creek Borefield flora and vegetation assessment (Niche 2011a - Appendix 10.12) were identified by Dr. Kelly Shepherd (Senior Research Scientist at the Western Australian Herbarium, Department of Parks and Wildlife, WA) and reports and data reviewed by samphire specialist Bindy

Datsun (Actis 2012 - Appendix 10.61). A total of 231 specimens were collected from the salt lakes, including 168 *Tecticornia* specimens. These specimens represented 21 *Tecticornia* taxa, including 16 recognised taxa (species, subspecies or phrase name taxa), two of which are Priority flora:

- *Tecticornia* sp. Lake Way (P. Armstrong 05/961) (Priority 1); and
- *Tecticornia cymbiformis* (now Priority 3).

An additional five unrecognised (potentially new) taxa were also recorded:

- *Tecticornia* sp. aff. *laevigata*;
- *Tecticornia* sp. aff. *pruinosa*;
- *Tecticornia* sp. aff. *undulata*;
- *Tecticornia* sp. *halocnemoides* beaked seed aggregate; and
- *Tecticornia* sp. nov.

Three vegetation units described in Niche (2011a - Appendix 10.12) were identified in Actis (2012 - Appendix 10.61) as being potentially groundwater dependent:

- Fr1 (Fringing *Melaleuca xerophila*);
- Cp2 (Dwarf scrub *Cratystylis subspinescens*); and
- Sl1 (Low Heath D *Tecticornia* spp.)

9.3.5 Millipede (Niche 2014 - Appendix 10.13)

A Level 2 flora and a vegetation assessment was undertaken in April 2010, June 2010 and September/October 2010 and October 2013 for Millipede deposit as part of the Toro Wiluna Uranium Project (Niche 2014 - Appendix 10.13). The survey included 30 quadrats (each 30 x 30 m) and sampled 185 vascular flora taxa with two Priority flora taxa recorded (both Priority 3 taxa: *Eremophila arachnoides* subsp*. arachnoides* and *Stackhousia clementii*). No introduced flora species were recorded. Ten vegetation units were described, including two significant vegetation units: Ca1 (Low woodland of *Acacia* species) which is considered to be of significance due to the presence of the Priority 3 *Eremophila arachnoides* subsp. *arachnoides*; and Sl (Low heath of *Tecticornia* species) which is considered to be of significance due to the presence of potentially new (undescribed) species and the presence of the Priority 3 *Stackhousia clementii* (Table 9.1).

9.3.6 Millipede to Lake Maitland Haul Road (Ecologia 2015a – Appendix 10.36)

A Level 2 flora and a vegetation assessment was undertaken in June 2014, October 2014, January 2015 and March 2015 of the haul road alignment between the Millipede and Lake Maitland deposits as part of the Toro Extension to the Wiluna Uranium Project (Ecologia 2015a – Appendix 10.36). The survey included 130 quadrats (each 30 x 30 m) and sampled 223 vascular flora taxa with five Priority flora taxa recorded (three Priority 3 taxa: *Cratystylis centralis*, *Stackhousia clementii* and *Tecticornia cymbiformis*, and two Priority 4 taxa: *Eremophila pungens* and *Frankenia confusa*). Three introduced flora species were recorded (**Bidens bipinnata*, **Citrullus* ?*lanatus* and **Tribulus terrestris*).

A total of 12 vegetation units were described, including two significant *Tecticornia* vegetation units: S (*Tecticornia* spp., *Frankenia cinerea, Maireana villosa* and *Atriplex amnicola* sparse low shrubland) and V (*Tecticornia* spp., *Cratystylis subspinescens*, *Maireana amoena* and *Sclerolaena diacantha* sparse mid shrubland, over *Eragrostis falcata* sparse tussock grassland) which are considered to be of significance due to the presence of potentially new (undescribed) species and restricted distribution (Table 9.1). All *Tecticornia* specimens from this assessment were provided to Dr. Kelly Shepherd (Senior Research Scientist at the Western Australian Herbarium, Department of Parks and Wildlife, WA) for identification. Refer Ecologia (2015a - Appendix 10.36) and Shepherd (2015 – Appendix 10.33).

9.3.7 Assessment of *Tecticornia* Communities of Lake Way and Lake Maitland (Ecologia 2015e - Appendix 10.7)

A *Tecticornia* assessment was undertaken at Lake Way and Lake Maitland in November 2014 and January 2015 as part of the Toro Extension to the Wiluna Uranium Project (Ecologia 2015e - Appendix 10.7). The survey included the identification of 134 specimens from 162 quadrats (3 x 3 m) as well as 77 specimens for the haul road survey (Ecologia 2015a - Appendix 10.36). All *Tecticornia* specimens were provided to Dr Kelly Shepherd for identification.

As well as the 16 known *Tecticornia* taxa, three Priority flora were identified:

- *Tecticornia* sp. Lake Way (P. Armstrong 05/961) (Priority 1);
- *Tecticornia* sp. Sunshine Lake (K.A. Shepherd et al. KS 867) (Priority 1); and
- *Tecticornia cymbiformis* (Priority 3).

Seven novel *Tecticornia* species were identified:

- *Tecticornia* aff. *halocnemoides* s.l. 'large ovate seed aggregate';
- *Tecticornia* aff. *halocnemoides* s.l. 'tuberculate seed'
- *Tecticornia* sp. aff *globulifera* (small);
- *Tecticornia* sp. aff *laevigata* (non-rotated fruitlets);
- *Tecticornia* sp. aff *pruinosa* (inflated bracts);
- *Tecticornia* sp. aff. Burnerbinmah (inflated fruit); and
- *Tecticornia* sp. aff. *undulata* (broad articles).

Six potentially novel taxa were identified:

- *Tecticornia* aff. *halocnemoides* (unusual epidermis);
- ?*Tecticornia* sp. aff. *globulifera* (small);
- *Tecticornia* sp. *halocnemoides* beaked seed aggregate;
- *Tecticornia* sp. aff. *laevigata*;
- *Tecticornia* sp. aff. *pruinosa*; and
- *Tecticornia* sp. aff. *undulata*.

Four range extensions were identified:

- *Tecticornia halocnemoides* subsp. *catenulate*;
- *Tecticornia moniliformis*;
- *Tecticornia pterygosperma* subsp. *pterygosperma*; and
- *Tecticornia tenuis*

Nine *Tecticornia* complexes were described.

- T1: *Tecticornia laevigata*, T. sp. aff *globulifera* (small) and T. sp. aff. *undulata* (broad articles) sparse low shrubland;
- T2: *Tecticornia peltata*, T. sp. aff *globulifera* (small), T. sp. aff. *undulata* (broad articles) and T. sp. Sunshine Lake (K.A. Shepherd *et al.* KS 867) sparse low shrubland;
- T3: *Tecticornia* sp. Dennys Crossing (K.A. Shepherd & J. English KS 552) (+/-T. *indica*, T. sp. aff. *undulata* (broad articles), T. sp. aff *globulifera* (small) and *Tecticornia* sp. Sunshine Lake (K.A. Shepherd et al. KS 867)) sparse low shrubland;
- T4: *Tecticornia* sp. Burnerbinmah (D. Edinger et al. 101) and *Tecticornia* sp. aff *globulifera* (small) (+/-T. *indica* subsp. *leiostachya* and *Tecticornia* aff *halocnemoides* s.l. 'large ovate seed aggregate') sparse low shrubland;
- T5: *Melaleuca xerophila* tall sparse shrubland, over *Tecticornia cymbiformis*, *Dissocarpus paradoxus*, and *Frankenia laxiflora* low shrubland, over *Enneapogon caerulescens* and *Eragrostis dielsii* sparse tussock grassland;

- T6: *Frankenia fecunda* (glabrous leaf variant) and *Tecticornia disarticulata* (+/- *Tecticornia indica* subsp. *bidens*) low sparse shrubland, over *Aristida holathera* and *Eragrostis falcata* sparse tussock grassland;
- T7: *Cratystylis subspinescens*, *Maireana amoena* and *Sclerolaena diacantha* (+/-*Tecticornia laevigata* and *Tecticornia indica*) sparse mid shrubland, over *Eragrostis falcata* sparse tussock grassland;
- T8: *Tecticornia* spp. (*Tecticornia indica* subsp. *bidens*, *Tecticornia* sp. aff *pruinosa*, *Tecticornia laevigata*, *Tecticornia* sp. aff. *undulata*, *Tecticornia peltata* and *Tecticornia* sp. (*halocnemoides* beaked seed aggregate) sparse low shrubland; and
- T9: *Acacia* victoriae and *Melaleuca xerophila* scattered tall shrubs, over *Lycium australe* and *Cratystylis subspinescens* sparse mid shrubland, over *Tecticornia* spp. (*Tecticornia indica* subsp. *bidens*, *Tecticornia* sp. aff *pruinosa*, *Tecticornia laevigata*, *Tecticornia* sp. aff. *undulata*, *Tecticornia peltata* and *Tecticornia* sp. (*halocnemoides* beaked seed aggregate) sparse low shrubland.

9.4 Existing Environment – Millipede Ore Haul Road and Lake Maitland

The following discussion adds to that provided in Section 9.3 about flora and vegetation.

9.4.1 Land Systems

To assist with placing the Proposal into the correct land systems, a digital dataset was acquired from the Department of Agriculture and Food, Western Australia. The digital dataset was used to determine the Land Systems and their extent within the area where the Proposal would be implemented.

The Millipede, Haul Road and Lake Maitland development envelopes are located in areas over which broad scale surveys have been completed (Mabbutt, 1963) and (Pringle *et al*., 1994).

The Millipede development envelope is located on two land systems. The Haul Road development envelope is located across 16 land systems. The Lake Maitland development envelope is located over six land systems. Figure 9.2 shows the land systems affected by the Proposal.

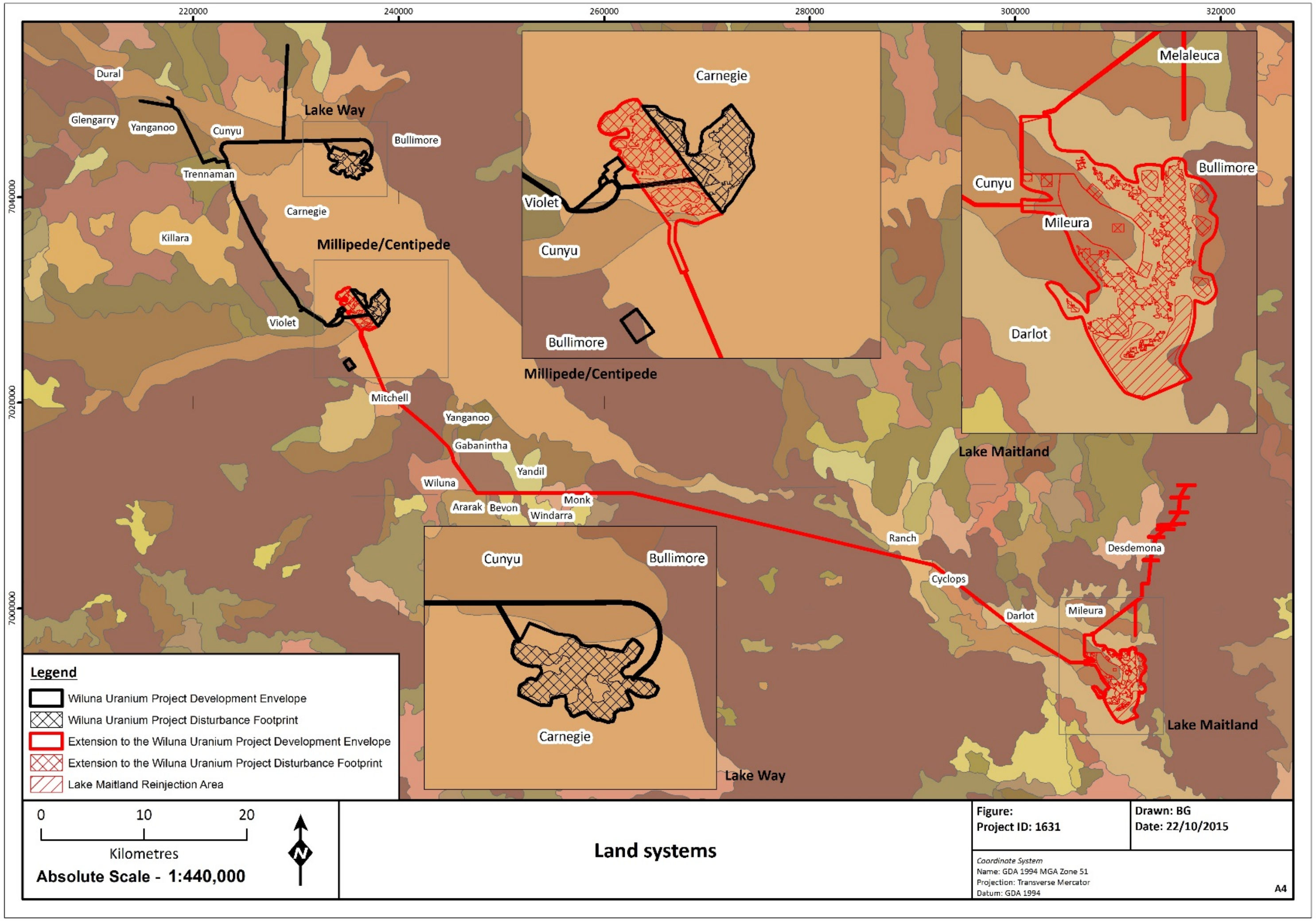
The proportion of each land system which occurs in the relevant study areas for the Proposal is presented in Table 9.2.

A regional survey of the Murchison was conducted by Curry *et al.* (1994) in an attempt to obtain an inventory and condition of land systems within the Murchison River catchment. The Murchison regional inventory covers approximately 88,360 sq km of arid zone rangelands situated between Mt Magnet and Meekatharra in the east and the catchments of the Greenough and Wooramel Rivers in the west. This area includes most of the catchment of the Murchison River and its tributaries the Sanford, Roderick and Yalgar Rivers; as well as most of the catchment of Lake Austin. A total of 19 land systems occur within the development envelope or disturbance footprint of the Wiluna Uranium Project and the Extension to the Wiluna Uranium Project, shown in Table 9.2 and mapped in Figure 9.2.

Table 9.2: Land systems and impacts (ha)

Land system	Extension to the Wiluna Uranium Project									Wiluna Uranium Project Disturbance	Cumulative Project Total Disturbance	Mapped extent in the Murchison
	Extent within development envelope				Extent within disturbance footprint envelope							
	Millipede	Haul Road	Lake Maitland	Lake Maitland Borefield	Millipede	Haul Road	Lake Maitland	Lake Maitland Borefield	Total Disturbance			
Ararak	-	1.1	-	-	-	0.9	-	-	0.9	-	0.9	149,890
Bullimore	-	151.4	46.3	18.6	-	121.4	3.0	18.6	143.0	48.8	191.8	3,564,992
Carnegie	710.0	15.1	-	-	525.7	12.1	-	-	537.8	1,352.7	1890.6	1,185,945
Cunyu	29.0	25.9	44.9	-	12.2	20.7	6.1	-	39.0	54.4	93.4	290,394
Cyclops	-	8.6	-	-	-	6.9	-	-	6.9	-	6.9	25,534
Darlot	-	17.1	1967.4	0.9	-	13.7	651.5	0.9	666.1	-	666.1	133,509
Desdemona	-	9.2	-	0.3	-	7.4	-	0.3	7.7	-	7.7	255,706
Gabanintha	-	9.4	-	-	-	7.5	-	-	7.5	22.5	30.0	165,109
Killara	-	-	-	-	-	-	-	-	-	2.8	2.8	133,194
Melaleuca	-	-	1.8	1.8	-	-	-	1.8	1.8	-	1.8	37,625
Mileura	-	-	765.3	2.0	-	-	115.8	2.0	117.8	-	117.9	206,496
Mitchell	-	8.1	-	-	-	6.5	-	-	6.5	-	6.5	26,622
Monk	-	11.0	-	-	-	8.8	-	-	8.8	-	8.8	996,801
Ranch	-	11.8	-	-	-	9.5	-	-	9.5	-	9.5	86,989
Trennaman	-	-	-	-	-	-	-	-	-	9.6	9.6	61,752
Violet	-	-	-	-	-	-	-	-	-	25.5	25.5	546,126
Wiluna	-	16.6	-	-	-	13.3	-	-	13.3	1.7	15.1	252,598
Windarra	-	13.3	-	-	-	10.6	-	-	10.6	-	10.6	227,973
Yanganoo	-	5.7	-	-	-	4.6	-	-	4.6	11.8	16.4	1,967,111
Total	**739.0**	**304.2**	**2,824.0**	**23.6**	**537.9**	**243.9**	**776.4**	**23.6**	**1,581.7**	**1,530.0**	**3,111.7**	**-**

Figure 9.2: Land systems covering the Wiluna Uranium Project and its Extension



Millipede

The Millipede tenements extend over the Carnegie and Cunyu land systems. The Carnegie system was characterised by Mabbutt (1963) as being salt lakes with surrounding dunes. It was divided into nine units, incorporating inner lake floors devoid of vegetation, lower margins and tributary plains hosting halophytic vegetation, higher margins and channels hosting mulga, kopi dunes with eucalypts, dunes of red sands hosting *Acacia* vegetation and fringing units of *Melaleuca* spp. (Mabbutt, 1963). The dominant units within the Carnegie system were the lake floors and the dunes, sand banks and higher plains.

The Cunyu land system was broadly categorised as calcrete valley floors comprised of depositional surfaces to 8 km wide (Mabbutt, 1963). The system includes calcrete platforms up to 5 m high, narrow alluvial floors between the higher areas and broader alluvial plains obscuring the calcrete. Within the Cunyu land system, six broad units were defined, of which 'calcrete platform' is the dominant unit. In this land system calcrete platforms and alluvial plains typically host mulga (*Acacia aneura*) and other *Acacia* species over mixed shrubs, grasses and forbs, while saline plains host halophytic communities and drainage channels and marginal zones host communities of *Eucalyptus microtheca* (Mabbutt, 1963).

Haul Road

The proposed haul road linking the Lake Maitland deposit to the previously assessed processing facility at Millipede-Centipede measures approximately 80 km and would be built to a maximum width of 30 m. The associated development envelope is estimated at 327.8 ha of which 304.2 ha is expected to be disturbed. Toro commissioned Ecologica to undertake surveys over a haul road study area of 80 km in length by 320 m in width for a total of 2475 ha (Ecologia, 2015a – Appendix 10.36). The Bullimore land system has the greatest extent within the study area, comprising 52.5% of the area. This is a large and widespread land system with a 4,418,645 ha area mapped in Western Australia. Each of the 15 other land systems within the haul road development envelope are well represented outside the study area, with the total extent of each land system ranging from 0.001% to 0.23%. One land system, Mitchell, is restricted in the Murchison IBRA region, with only 26,622 ha mapped.

Lake Maitland

Lake Maitland is located within the Eastern Murchison subregion of the Murchison Bioregion (Thackway and Cresswell, 1995) and incorporates six land systems: Darlot, Mileura, Cunya, Bullimore, *Melaleuca* and Desdemona.

The Bullimore and Darlot dominate the area in which the Proposal would be implemented (Pringle *et al*., 1994). The Darlot land system is represented by the Lake Maitland playa and fringing saline alluvial plains, while the Bullimore land system is represented by extensive spinifex sandplains to the east of the lake.

The broad landscape is arid and flat, with surface slopes at less than 0.06% over the majority of the catchment, reducing to less than 0.05% in the vicinity of Lake Maitland.

9.4.2 Vegetation

Beard Vegetation Mapping

The vegetation of Western Australia was originally mapped at the 1:1,000,000 scale by Beard (1976), and was subsequently reinterpreted and updated to reflect the National Vegetation Information System (NVIS) standards (Shepherd *et al.* 2001).

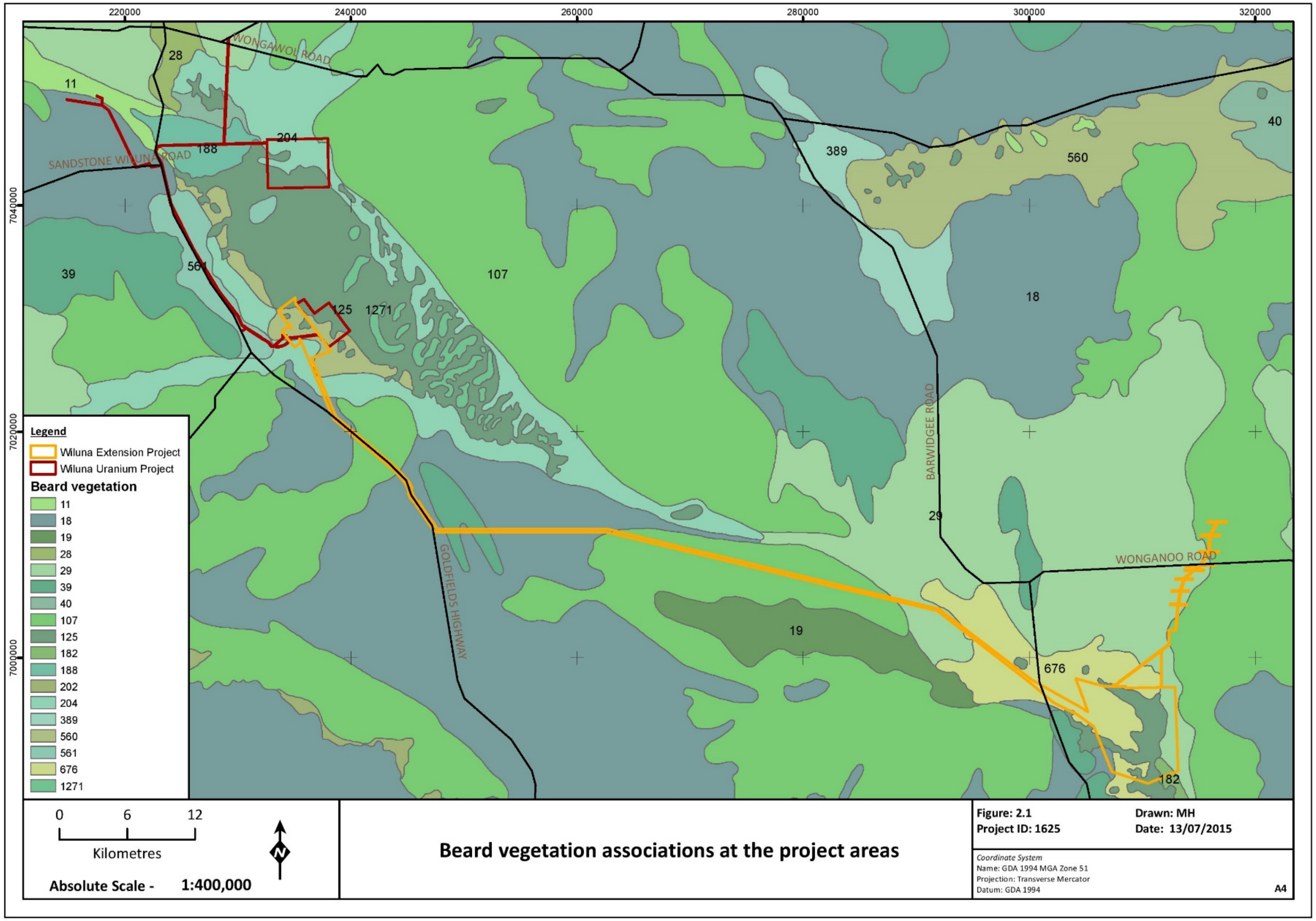
Across the Wiluna Uranium Project and its Extension, 13 vegetation associations have been mapped which are described in Table 9.3 and shown in Figure 9.3.

Of these, associations 125 (Bare areas; salt lakes) and 560 (Mosaic: Shrublands; *Acacia ramulosa* scrub/succulent steppe; Samphire) were the most common. Eight associations are considered restricted in the region, of which association 561: Succulent steppe with low woodland; mulga over saltbush is the most regionally restricted with 8,966 ha mapped within the Murchison IBRA bioregion (Table 9.3).

Table 9.3: Shepherd (Beard) vegetation associations at the study area

Vegetation code (Shepherd et al., 2001)	Vegetation association (Beard 1976)	Total area in project areas (ha)	Area mapped in the Murchison (ha)	% total area mapped in the Murchison & (% regional distribution)
11	Medium woodland; coolabah (*Eucalyptus microtheca*)	2.3	9,195	<0.1% (Restricted)
18	Low woodland; Mulga (*Acacia aneura*)	144.9	12,435,564	44.1% (Widespread)
29	Sparse low woodland; Mulga, discontinuous in scattered groups	94.0	2,974,137	10.5% (Widespread)
39	Shrublands; Mulga scrub	9.1	1,152,458	4.1% (Moderate)
40	Shrublands; *Acacia* scrub, various species	6.0	59,230	0.2% (Restricted)
107	Hummock grasslands, shrub steppe; Mulga and *Eucalyptus kingsmillii* over hard spinifex	105.9	2,794,374	9.9% (Widespread)
125	Bare areas; salt lakes	1,399.7	712,038	2.5% (Moderate)
182	Low woodland; Mulga & *Acacia ramulosa*	3.6	51,015	0.2% (Restricted)
188	Shrublands; mulga and *Acacia sclerosperma* scrub	21.6	11,990	<0.1% (Restricted)
204	Succulent steppe with open scrub; scattered Mulga & *Acacia sclerosperma* over saltbush & bluebush	439.9	186,550	0.7% (Restricted)
560	Mosaic: Shrublands; *Acacia ramulosa* scrub/succulent steppe; Samphire	693.6	84,797	0.3% (Restricted)
561	Succulent steppe with low woodland; mulga over saltbush	38.5	8,966	<0.1% (Restricted)
676	Succulent steppe; Samphire	152.6	383,163	1.4% (Restricted)

Figure 9.3: Beard vegetation associations



Toro Vegetation Mapping

Studies commissioned by Toro have identified a total of 31 vegetation units based on an analsyis of data from all quadrats surveyed for the Wiluna Uranium Project, including its Extension. These vegetation units and bare salt lake bed (with no vegetation cover) were mapped across a total area of 33,272.0 ha, incorporating all areas mapped from the flora and vegetation assessments for the Wiluna Uranium Project and its Extension.

Of these vegetation units, 21 were recorded at the Wiluna Uranium Project and 25 in areas where it would be extended. These are described in Table 9.4 and shown in Figure 9.4. Detailed vegetation mapping is presented in Ecologia 2015g - Appendix 10.49. The dendrogram showing the delineated vegetation communities used in this report is presented in Appendix B of Ecologia 2015g (Appendix 10.49 of the PER).

The 13 Beard vegetation units (Figure 9.3) mapped within the Project area have been compared to the 31 vegetation units. Using the total mapped area of each Beard unit in the Murchison region, eight units; 11, 40, 182, 188, 204, 560, 561 and 676 have restricted distributions (Table 9.6). These units are generally associated with salt lakes or saline depressions and often have a Chenopodiaceae understory.

Table 9.4: Vegetation units

Code	Vegetation unit description	Mapped extent, average species richness, landform and quadrats	Associated species	Photograph
AA	*Acacia tetragonophylla* sparse tall shrubland, over *Senna artemisioides* and *Ptilotus obovatus* sparse low shrubland.	Extent: 2,560.0 ha Average species richness: 8.8 ± 3.4 Landform: Plain Number of quadrats: 24	*Acacia aneura/aptaneura* *Acacia burkittii* *Acacia pteraneura/macraneura* *Eremophila longifolia* *Hakea francisiana* *Rhagodia eremaea* *Scaevola spinescens*	
AB	*Acacia tetragonophylla, Acacia victoriae* and *Ptilotus obovatus* sparse low shrubland.	Extent: 465.0 ha Average species richness: 5.8 ± 1.9 Landform: Plain Number of quadrats: 5	*Acacia aneura/aptaneura* *Acacia burkittii* *Eremophila arachnoides* subsp. *arachnoides* *Grevillea nematophylla* *Senna artemisioides*	
AC	*Eucalyptus camaldulensis* subsp. *obtusa* sparse low woodland, over *Acacia aptaneura* and *Acacia tetragonophylla* sparse tall shrubland, over *Eremophila longifolia, Senna artemisioides* and *Scaevola spinescens* sparse mid shrubland.	Extent: 3,009.2 ha Average species richness: 10.5 ± 3.5 Landform: Plain Number of quadrats: 15	*Acacia aneura/aptaneura* *Acacia victoriae* *Eragrostis eriopoda* *Grevillea nematophylla* *Hakea francisiana/minyma* *Ptilotus obovatus* *Rhagodia eremaea* *Santalum lanceolatum*	

Code	Vegetation unit description	Mapped extent, average species richness, landform and quadrats	Associated species	Photograph
BA	*Acacia aneura/aptaneura* sparse low woodland, over *Acacia tetragonophylla* (+/- *Melaleuca hamata*) sparse tall shrubland, over *Senna artemisioides*, *Scaevola spinescens* and *Rhagodia drummondii* sparse mid shrubland, over *Ptilotus obovatus*, *Maireana villosa, Sclerolaena diacantha* and *Cratystylis subspinescens* sparse low shrubland.	Extent: 92.3 ha Average species richness: 14.5 ± 3.1 Landform: Plain Number of quadrats: 13	*Acacia pteraneura/macraneura* *Atriplex amnicola* *Enchylaena tomentosa var. tomentosa* *Enteropogon ramosus* *Eremophila galeata* *Exocarpos aphyllus* *Maireana triptera* *Melaleuca xerophila* *Pittosporum phylliraeoides* *Sclerolaena densiflora* *Solanum lasiophyllum* *Solanum nummularium*	
BB	*Casuarina pauper* open low woodland, over *Eremophila pantonii, Eremophila longifolia* and *Eremophila latrobei* sparse mid shrubland, over *Scaevola spinescens, Exocarpos aphyllus*, *Rhagodia drummondii* and *Ptilotus obovatus* sparse low shrubland.	Extent: 1,105.6 ha Average species richness: 15.7 ± 2.3 Landform: Plain Number of quadrats: 7	*Acacia nyssophylla* *Eremophea spinosa* *Eremophila forrestii* *Eriochiton sclerolaenoides* *Hakea preissii* *Sclerolaena diacantha* *Sclerolaena obliquicuspis* *Senna artemisioides* *Sida* sp. dark green fruits (S. van Leeuwen 2260) *Solanum lasiophyllum*	No photograph available

Code	Vegetation unit description	Mapped extent, average species richness, landform and quadrats	Associated species	Photograph
BC	*Scaevola spinescens, Eremophila malacoides, Rhagodia drummondii, Maireana villosa* and *Eremophila glabra* sparse low shrubland, over *Enteropogon ramosus* sparse tussock grassland.	Extent: 59.7 ha Average species richness: 11.3 ± 2.3 Landform: Plain Number of quadrats: 3	*Enchylaena tomentosa* var. *tomentosa* *Eremophila forrestii* *Eremophila glandulifera* *Eremophila longifolia* *Exocarpos aphyllus* *Grevillea extorris* *Sclerolaena diacantha* *Triodia basedowii*	
BD	*Acacia aneura/aptaneura* sparse low woodland, over *Maireana pyramidata, Maireana triptera* and *Atriplex bunburyana* open low shrubland.	Extent: 180.3 ha Average species richness: 10.7 ± 3.8 Landform: Plain Number of quadrats: 6	*Enchylaena tomentosa* var. *tomentosa* *Enteropogon ramosus* *Eremophila forrestii* *Eremophila longifolia* *Maireana georgei* *Rhagodia drummondii* *Sclerolaena cuneata* *Sida fibulifera* *Solanum lasiophyllum*	
CA	*Acacia aneura/aptaneura* sparse low woodland, over *Acacia burkittii* open tall shrubland*, over Eremophila galeata*, *Eremophila compacta, Senna sp. Meekatharra (E. Bailey 1-26), Senna artemisioides and Sida ectogama* sparse mid shrubland, over *Monachather paradoxus* open tussock grassland.	Extent: 34.6 ha Average species richness: 16 ± 4.5 Landform: Undulating plain and rocky hillslope Number of quadrats: 6	*Solanum lasiophyllum* *Acacia tetragonophylla* *Indigofera monophylla* *Scaevola spinescens* *Eragrostis eriopoda* *Eremophila oldfieldii* *Ptilotus obovatus* *Maireana thesioides* *Hibiscus burtonii* *Senna glaucifolia* *Eremophila pantonii*	

Code	Vegetation unit description	Mapped extent, average species richness, landform and quadrats	Associated species	Photograph
CB	*Acacia aneura/aptaneura* open low woodland, over *Acacia burkittii* and *Acacia tetragonophylla* sparse tall shrubland, over *Senna artemisioides x artemisioides*, *Senna glaucifolia* and *Eremophila galeata* open mid shrubland, over *Aristida contorta* open tussock grassland.	Extent: 6.6 ha Average species richness: 27.5 ± 2.1 Landform: Drainage line Number of quadrats: 2	*Abutilon otocarpum* *Acacia craspedocarpa* *Cheilanthes sieberi* subsp. *sieberi* *Cyperus betchei* subsp. *commiscens* *Digitaria brownii* *Eremophila clarkei* *Eremophila compacta* *Indigofera monophylla* *Paspalidium gracile* *Pluchea dentex* *Sclerolaena diacantha* *Themeda triandra*	
CC	*Acacia pteraneura/macraneura* isolated low trees, over *Eremophila galeata, Senna artemisioides* and *Sida ectogama* sparse mid shrubland, over *Eragrostis eriopoda* and *Monachather paradoxus* open tussock grassland.	Extent: 122.2 ha Average species richness: 13.5 ± 4.1 Landform: Plain Number of quadrats: 13	*Acacia aneura/aptaneura* *Acacia burkittii/quadrimarginea* *Acacia craspedocarpa* *Acacia tetragonophylla* *Eremophila latrobei* *Maireana thesioides* *Psydrax rigidula* *Ptilotus obovatus* *Solanum lasiophyllum*	

Code	Vegetation unit description	Mapped extent, average species richness, landform and quadrats	Associated species	Photograph
CD	*Acacia aneura/aptaneura, Acacia pteraneura/macraneura* and *Acacia craspedocarpa* low woodland, over *Eremophila gilesii*, *Eremophila galeata* and *Senna artemisioides* sparse mid shrubland, over *Sida* sp. verrucose glands (F.H. Mollemans 2423), *Solanum lasiophyllum* and *Abutilon cryptopetalum* sparse low shrubland, over *Digitaria brownii, Eragrostis eriopoda* and *Monachather paradoxus* sparse tussock grassland.	Extent: 25.4 ha Average species richness: 19.1 ± 3.6 Landform: Plain, floodplain, drainage lines Number of quadrats: 8	*Acacia ayersiana/caesaneura* *Acacia tetragonophylla* *Duperreya commixta* *Eremophila latrobei* *Eremophila margarethae* *Maireana thesioides* *Psydrax rigidula* *Psydrax suaveolens* *Rhyncharrhena linearis* *Santalum spicatum* *Sida ectogama* *Spartothamnella teucriiflora*	
D	*Acacia aneura/aptaneura* and *Acacia ayersiana/caesaneura* open low woodland (+/-*Acacia tetragonophylla* and *Acacia pruinocarpa*), over *Eremophila forrestii, Eremophila latrobei, Eremophila foliosissima* sparse mid shrubland, over *Eragrostis eriopoda* sparse tussock grassland and *Triodia melvillei* sparse hummock grassland.	Extent: 9,226.8 ha Average species richness: 9.3 ± 2.7 Landform: Plain, floodplain, drainage lines Number of quadrats: 41	*Acacia craspedocarpa* *Acacia rhodophloia* *Cheilanthes sieberi* subsp. *sieberi* *Eremophila congesta* *Psydrax rigidula* *Psydrax suaveolens* *Ptilotus schwartzii* *Rhagodia drummondii* *Rhagodia eremaea* *Senna glaucifolia* *Spartothamnella teucriiflora*	

Code	Vegetation unit description	Mapped extent, average species richness, landform and quadrats	Associated species	Photograph
E	*Acacia aneura/aptaneura/ayersiana/caesaneura* (+/-*Eucalyptus gypsophila*) sparse low woodland, over *Acacia nyssophylla*, *Eremophila arachnoides* subsp. *arachnoides* and *Acacia victoriae* sparse mid to tall shrubland, over *Ptilotus obovatus, Sclerolaena obliquicuspis* and *Rhagodia eremaea* sparse low shrubland, over *Eragrostis eriopoda* sparse tussock grassland.	Extent: 630.3 ha Average species richness: 6.5 ± 3.4 Landform: Plain Number of quadrats: 17	*Acacia burkittii* *Acacia ligulata* *Acacia oswaldii* *Casuarina pauper* *Dodonaea viscosa* *Eremophila latrobei* *Maireana pyramidata* *Scaevola spinescens* *Senna artemisioides* *Solanum lasiophyllum*	
F	+/- *Acacia victoriae* and/or *Melaleuca interioris* sparse tall shrubland, over *Eremophila glabra, Scaevola spinescens*, *Rhagodia eremaea* and *Lycium australe* sparse low shrubland.	Extent: 86.9 ha Average species richness: 6 ± 2.3 Landform: Plain Number of quadrats: 12	*Acacia burkittii* *Acacia nyssophylla* *Atriplex amnicola* *Eragrostis eriopoda* *Eremophila arachnoides* subsp. *arachnoides* *Maireana pyramidata* *Muellerolimon salicorniaceum* *Sclerolaena fimbriolata* *Sclerolaena obliquicuspis*	
G	*Acacia incurvaneura* woodland (+/-*Acacia craspedocarpa* and *Acacia ramulosa* var. *linophylla*), over *Eremophila maculata* and *Scaevola spinescens* shrubland over *Triodia melvillei* open hummock grassland.	Extent: 32.6 ha Average species richness: 6 ± 2.3 Landform: Plain Number of quadrats: 12	*Acacia pruinocarpa* *Eremophila latrobei*	

Code	Vegetation unit description	Mapped extent, average species richness, landform and quadrats	Associated species	Photograph
H	+/- *Eucalyptus striaticalyx* and *Acacia aneura/aptaneura* sparse low woodland, over *Eremophila glabra* and *Senna artemisioides* sparse mid shrubland, over *Dissocarpus paradoxus, Eremophila oppositifolia* and *Sclerolaena bicornis* sparse low shrubland.	Extent: 6.2 ha Average species richness: 5.8 ± 1.9 Landform: Plain Number of quadrats: 4	*Acacia victoriae* *Acacia xanthocarpa* *Amyema maidenii* *Atriplex bunburyana* *Maireana villosa* *Rhyncharrhena linearis* *Santalum spicatum*	
I	+/- *Acacia aneura/aptaneura* isolated low trees, over *Lycium australe, Rhagodia drummondii*, *Frankenia pauciflora* sens. lat. and *Lawrencia squamata* open low shrubland.	Extent: 1,121.0 ha Average species richness: 5.7 ± 2.9 Landform: Plain, floodplain Number of quadrats: 4	*Acacia ayersiana/caesaneura* *Atriplex amnicola* *Cratystylis subspinescens* *Eragrostis eriopoda* *Exocarpos aphyllus* *Frankenia setosa* *Maireana amoena* *Scaevola spinescens* *Sclerolaena cornishiana* *Sclerolaena parviflora* *Triodia basedowii*	
J	+/- *Casuarina pauper* sparse low woodland, over *Atriplex bunburyana, Lycium australe, Lawrencia squamata* and *Ptilotus obovatus* sparse low to mid shrubland, over *Eragrostis setifolia* sparse tussock grassland.	Extent: 548.5 ha Average species richness: 9.7 ± 2.5 Landform: Plain, floodplain, near salt lakes Number of quadrats: 15	*Acacia tetragonophylla* *Eragrostis eriopoda* *Hakea preissii* *Rhagodia eremaea* *Sclerolaena cornishiana* *Senna artemisioides* *Solanum lasiophyllum*	

Code	Vegetation unit description	Mapped extent, average species richness, landform and quadrats	Associated species	Photograph
K	*Casuarina obesa* open low woodland, over *Acacia nyssophylla* sparse tall shrubland, over *Lycium australe* and *Sclerolaena fimbriolata* sparse low shrubland.	Extent: 19.7 ha Average species richness: 5.3 ± 0.6 Landform: Plain Number of quadrats: 3	*Eremophea spinosa* *Eremophila falcata* *Ptilotus obovatus* *Senna artemisioides* *Senna glutinosa*	No photograph available
L	+/- *Acacia aneura/aptaneura* and *Hakea lorea* subsp. *lorea* isolated low trees, over *Alyogyne pinoniana, Androcalva loxophylla*, *Solanum coactiliferum* and *Leptosema chambersii* sparse low shrubland, over *Triodia basedowii* open hummock grassland and *Eragrostis eriopoda* sparse tussock grassland.	Extent: 283.4 ha Average species richness: 8 ± 3.6 Landform: Sandy plain Number of quadrats: 27	*Dicrastylis exsuccosa* *Dicrastylis flexuosa* *Eremophila forrestii* *Eremophila longifolia* *Eremophila platythamnos* *Eucalyptus eremicola* subsp. *peeneri* *Melaleuca eleuterostachya* *Monachather paradoxus* *Ptilotus obovatus*	
M	*Acacia aneura/aptaneura* (+/-*Acacia ayersiana/caesaneura*) open low woodland, over *Eremophila forrestii, Eremophila spectabilis* subsp. *brevis* open mid shrubland, over *Triodia basedowii* open hummock grassland and *Eragrostis eriopoda* and *Monachather paradoxus* sparse tussock grassland.	Extent: 1,562.7 ha Average species richness: 12.8 ± 3.5 Landform: Plain, sandy plain Number of quadrats: 37	*Acacia minyura* *Acacia pruinocarpa* *Acacia pteraneura/macraneura* *Acacia tetragonophylla* *Eremophila gilesii* *Eremophila latrobei* *Maireana villosa* *Psydrax rigidula* *Psydrax suaveolens* *Ptilotus obovatus* *Sida fibulifera* *Sida* sp. dark green fruits	

Code	Vegetation unit description	Mapped extent, average species richness, landform and quadrats	Associated species	Photograph
N	*Acacia ayersiana/caesaneura* open low woodland (+/-*Acacia aneura/aptaneura* and *Eucalyptus eremicola* subsp. *peeneri*) open low woodland, over +/- *Melaleuca interioris* sparse tall shrubland, over *Triodia basedowii* open hummock grassland and *Eragrostis eriopoda* sparse tussock grassland.	Extent: 800.5 ha Average species richness: 14.7 ± 5.2 Landform: Plain, sandy plain Number of quadrats: 46	*Acacia tetragonophylla* *Cratystylis subspinescens* *Enchylaena tomentosa* var. *tomentosa* *Enteropogon ramosus* *Eremophila forrestii* *Grevillea sarissa* *Ptilotus obovatus* *Rhagodia drummondii* *Scaevola spinescens* *Senna artemisioides* *Solanum lasiophyllum*	
O	*Acacia ayersiana/caesaneura* open low woodland (+/- *Eucalyptus eremicola* subsp. *peeneri*) open low woodland, over *Triodia melvillei* open hummock grassland.	Extent: 3,987.8 ha Average species richness: 9 ± 3 Landform: Plain, sandy plain Number of quadrats: 55	*Acacia aneura/aptaneura* *Acacia ligulata* *Acacia oswaldii* *Eremophila forrestii* *Eremophila glabra* *Eremophila longifolia* *Grevillea sarissa* *Maireana pyramidata* *Ptilotus obovatus* *Rhagodia eremaea* *Scaevola spinescens* *Senna artemisioides*	

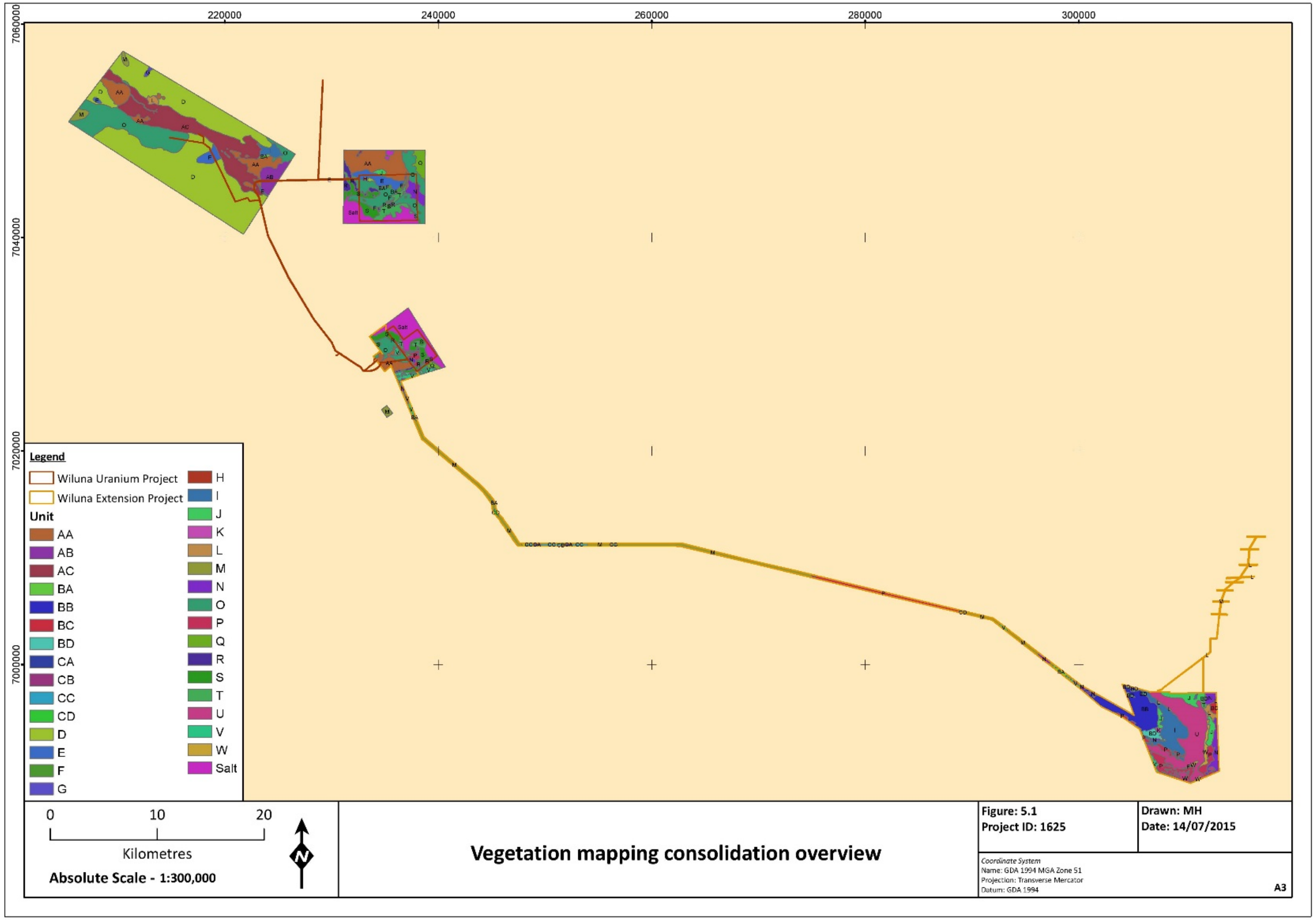
Code	Vegetation unit description	Mapped extent, average species richness, landform and quadrats	Associated species	Photograph
P	+/- *Acacia ayersiana/caesaneura* sparse low woodland, over *Acacia ligulata* and *Acacia jamesiana* sparse mid shrubland, over *Halgania cyanea* sparse low shrubs, over *Triodia basedowii* open hummock grassland.	Extent: 1,144.1 ha Average species richness: 11.6 ± 3.4 Landform: Plain, sandy plain Number of quadrats: 27	*Callitris columellaris* *Dodonaea viscosa* *Eragrostis eriopoda* *Eremophila miniata* *Eucalyptus eremicola* subsp. *peeneri* *Grevillea sarissa* *Monachather paradoxus* *Ptilotus obovatus* *Scaevola spinescens* *Scaevola tomentosa* *Senna artemisioides* *Solanum lasiophyllum*	
Q	*Callitris columellaris* sparse tall shrubland, over *Triodia melvillii* open hummock grassland.	Extent: 288.5 ha Average species richness: 5.4 ± 1.5 Landform: Plain, sandy plain Number of quadrats: 7	*Acacia jennerae* *Acacia ligulata* *Acacia prainii* *Eragrostis eriopoda* *Eucalyptus eremicola* subsp. *peeneri* *Grevillea juncifolia* *Grevillea sarissa* *Halgania cyanea* *Scaevola tomentosa* *Solanum lasiophyllum*	

Code	Vegetation unit description	Mapped extent, average species richness, landform and quadrats	Associated species	Photograph
R	*Melaleuca xerophila* open tall shrubland, over *Muellerolimon salicorniaceum* sparse low shrubland, over *Eragrostis eriopoda* sparse tussock grassland.	Extent: 325.1 ha Average species richness: 5.4 ± 1.5 Landform: Plain, sandy plain Number of quadrats: 7	*Acacia ayersiana/caesaneura* *Amyema microphylla* *Enchylaena tomentosa* var. *tomentosa* *Eremophea spinosa* *Ptilotus obovatus* *Rhagodia drummondii* *Rhagodia eremaea* *Scaevola spinescens* *Sclerolaena bicornis* *Sclerolaena obliquicuspis* *Senna artemisioides* *Solanum lasiophyllum*	
S	*Tecticornia* spp., *Frankenia cinerea, Maireana villosa* and *Atriplex amnicola* sparse low shrubland.	Extent: 821.2 ha Average species richness: 4.2 ± 1.9 Landform: Salt lake, salt pan Number of quadrats: 24	*Atriplex bunburyana* *Disphyma crassifolium* *Eremophila glabra* *Frankenia pauciflora sens. lat.* *Maireana luehmannii* *Muellerolimon salicorniaceum* *Panicum effusum* *Rhagodia eremaea* *Sclerolaena fimbriolata* *Solanum lasiophyllum* *Zygophyllum aurantiacum*	

Code	Vegetation unit description	Mapped extent, average species richness, landform and quadrats	Associated species	Photograph
T	*Tecticornia* spp., *Cratystylis subspinescens* and *Scaevola spinescens* sparse low shrubland.	Extent: 431.4 ha Average species richness: 2.1 ± 1.9 Landform: Salt lake, salt pan Number of quadrats: 11	*Acacia tetragonophylla* *Atriplex bunburyana* *Enteropogon ramosus* *Eremophila glabra*	
U	*Tecticornia* spp., *Maireana amoena* and *Scaevola collaris* sparse low shrubland, over *Eragrostis lanipes* sparse tussock grassland.	Extent: 1,984.1 ha Average species richness: 4.2 ± 1.2 Landform: Salt lake, salt pan Number of quadrats: 11	*Atriplex nana* *Frankenia cinerea* *Sclerolaena fimbriolata* *Lawrencia helmsii* *Lawrencia glomerata* *Maireana oppositifolia*	

Code	Vegetation unit description	Mapped extent, average species richness, landform and quadrats	Associated species	Photograph
V	*Tecticornia* spp., *Cratystylis subspinescens, Maireana amoena* and *Sclerolaena diacantha* sparse mid shrubland, over *Eragrostis falcata* sparse tussock grassland.	Extent: 324.0 ha Average species richness: 10.3 ± 3.6 Landform: Floodplain, salt pan, tributary Number of quadrats: 22	*Atriplex codonocarpa* *Enteropogon ramosus* *Eremophila malacoides* *Frankenia fecunda* *Frankenia laxiflora* *Melaleuca interioris* *Melaleuca xerophila* *Ptilotus obovatus* *Rhagodia drummondii* *Scaevola spinescens* *Sclerolaena cuneata* *Sclerolaena deserticola* *Solanum lasiophyllum*	No photograph available
W	*Eucalyptus striaticalyx* sparse low woodland, over *Grevillea sarissa* sparse tall shrubland, over *Lawrencia helmsii* sparse low shrubland.	Extent: 172.9 ha Average species richness: 5.6 ± 3.2 Landform: Floodplain, salt pan, tributary Number of quadrats: 8	*Acacia oswaldii* *Atriplex amnicola* *Atriplex nana* *Enchylaena tomentosa* var. *tomentosa* *Eragrostis falcata* *Eragrostis lanipes* *Eragrostis setifolia* *Eremophila latrobei* *Eremophila margarethae* *Frankenia pauciflora sens. lat.* *Maireana pentatropis* *Sclerolaena fimbriolata*	

Figure 9.4: Vegetation units – Wiluna Uranium Project and its Extension



Significant Vegetation

An assessment of the significance of vegetation at a regional level is constrained by the lack of mapping across the region at a scale comparable to the mapping commissioned by Toro during the current assessment (Ecologia 2015g – Appendix 10.49).

The only source of vegetation mapping available across the Murchison is that conducted by Beard (1976) (and digitised by Shepherd *et al.* (2001)), at a scale of 1:1,000,000. As it is completed at such a large scale, it does not accurately represent the mapped communities of the Project area, especially the minor details including drainage channels, creeklines and low hill slopes. If a vegetation unit mapped within the Project area can be attributed to a Beard vegetation unit, it can be used to assess the potential extent of this community in the region.

Threatened and Priority Ecological Communities

No Commonwealth or State listed TECs were recorded as occurring within 50 km of the areas where mining would be undertaken. No State vegetation units likely to be TECs were recorded. Within 50 km of the Project area, 11 PECs were recorded, of which five occur within the Project area:

- Barwidgee calcrete groundwater assemblage type on Carey palaeodrainage on Barwidgee Station;
- Hinkler Well calcrete groundwater assemblage type on Carey palaeodrainage on Lake Way Station;
- Lake Violet south and Lake Violet calcrete groundwater assemblage types on Carey palaeodrainage on Millbillillie Station;
- Uramurdah Lake calcrete groundwater assemblage type on Carey palaeodrainage on Millbillillie Station; and
- Wiluna BF calcrete groundwater assemblage type on Carey palaeodrainage on Millbillillie Station.

The five PECs are underground invertebrate assemblages and are not pertinent to the flora and vegetation of the Project area.

The closest PECs that are relevant to the flora and vegetation are the Wiluna West vegetation complexes (Banded Ironstone Formation), approximately 20 km west of the Project and the Violet Range vegetation complexes (Banded Ironstone Formation), approximately 40 km south.

Table 9.5: PECs within 50 km of the Project areas

Community	Category	Within Project areas
Albion Downs calcrete groundwater assemblage type on Carey palaeodrainage on Albion Downs Station	Priority 1	No
Barwidgee calcrete groundwater assemblage type on Carey palaeodrainage on Barwidgee Station	Priority 1	Yes
Hinkler Well calcrete groundwater assemblage type on Carey palaeodrainage on Lake Way Station	Priority 1	Yes
Lake Violet south and Lake Violet calcrete groundwater assemblage types on Carey palaeodrainage on Millbillillie Station	Priority 1	Yes
Lake Way South calcrete groundwater assemblage type on Carey palaeodrainage on Lake Way Station	Priority 1	No
Millbillillie Bubble Well groundwater calcrete assemblage type on Carey palaeodrainage on Millbillillie Station	Priority 1	No
Uramurdah Lake calcrete groundwater assemblage type on Carey palaeodrainage on Millbillillie Station	Priority 1	Yes
Violet Range (Perseverance Greenstone Belt) vegetation complexes (banded ironstone formation)	Priority 1	No

Community	Category	Within Project areas
Wiluna BF calcrete groundwater assemblage type on Carey palaeodrainage on Millbillillie Station	Priority 1	Yes
Wiluna West vegetation complexes (banded ironstone formation)	Priority 1	No
Yeelirrie calcrete groundwater assemblage type on Carey palaeodrainage on Yeelirrie Station	Priority 1	No

Vegetation of Local Significance

The local conservation significance of the 31 vegetation units recorded within the Project area is assessed in Table 9.7. Of these, four are considered to have a high local significance, 13 have a moderate local significance and 14 have a low local significance.

Table 9.6: Comparing Beard vegetation mapping and vegetation units for regional significance

Unit code	Vegetation unit description	Mapped extent, average species richness, landform and quadrats	Corresponding Beard Unit	% total area mapped in the Murchison* & (regional distribution)	Regional significance
AA	*Acacia tetragonophylla* sparse tall shrubland, over *Senna artemisioides* and *Ptilotus obovatus* sparse low shrubland.	Extent: 2,560.0 ha Average species richness: 8.8 ± 3.4 Landform: Plain Number of quadrats: 24	204: Succulent steppe with open scrub; scattered Mulga & *Acacia sclerosperma* over saltbush & bluebush	0.9% (Restricted)	Low: also recorded at the borefields in other widespread units
			560: Mosaic: Shrublands; Bowgada scrub/succulent steppe; Samphire	0.4% (Restricted)	
			676: Succulent steppe; Samphire	1.8% (Restricted)	
AB	*Acacia tetragonophylla, Acacia victoriae* and *Ptilotus obovatus* sparse low shrubland.	Extent: 465.0 ha Average species richness: 5.8 ± 1.9 Landform: Plain Number of quadrats: 5	188: Shrublands; mulga and *Acacia sclerosperma* scrub	<0.1% (Restricted)	High
AC	*Eucalyptus camaldulensis* subsp. *obtusa* sparse low woodland, over *Acacia aptaneura* and *Acacia tetragonophylla* sparse tall shrubland, over *Eremophila longifolia, Senna artemisioides* and *Scaevola spinescens* sparse mid shrubland.	Extent: 3,009.2 ha Average species richness: 10.5 ± 3.5 Landform: Plain Number of quadrats: 15	11: Medium woodland; coolabah (*Eucalyptus microtheca*)	<0.1% (Restricted)	High
BA	*Acacia aneura/aptaneura* sparse low woodland, over *Acacia tetragonophylla* (+/- *Melaleuca hamata*) sparse tall shrubland, over *Senna artemisioides*, *Scaevola spinescens* and *Rhagodia drummondii* sparse mid shrubland, over *Ptilotus obovatus*, *Maireana villosa*, *Sclerolaena diacantha* and *Cratystylis subspinescens* sparse low shrubland.	Extent: 92.3 ha Average species richness: 14.5 ± 3.1 Landform: Plain Number of quadrats: 13	676: Succulent steppe; Samphire	1.8% (Restricted)	High
BB	*Casuarina pauper* open low woodland, over *Eremophila pantonii, Eremophila longifolia* and *Eremophila latrobei* sparse mid shrubland, over *Scaevola spinescens, Exocarpos aphyllus*, *Rhagodia drummondii* and *Ptilotus obovatus* sparse low shrubland.	Extent: 1,105.6 ha Average species richness: 15.7 ± 2.3 Landform: Plain Number of quadrats: 7	676: Succulent steppe; Samphire	1.8% (Restricted)	High

Unit code	Vegetation unit description	Mapped extent, average species richness, landform and quadrats	Corresponding Beard Unit	% total area mapped in the Murchison* & (regional distribution)	Regional significance
BC	*Scaevola spinescens, Eremophila malacoides, Rhagodia drummondii, Maireana villosa* and *Eremophila glabra* sparse low shrubland, over *Enteropogon ramosus* sparse tussock grassland.	Extent: 59.7 ha Average species richness: 11.3 ± 2.3 Landform: Plain Number of quadrats: 3	29: Sparse low woodland; Mulga, discontinuous in scattered groups	14.3% (Widespread)	Low
BD	*Acacia aneura/aptaneura* sparse low woodland, over *Maireana pyramidata, Maireana triptera* and *Atriplex bunburyana* open low shrubland.	Extent: 180.3 ha Average species richness: 10.7 ± 3.8 Landform: Plain Number of quadrats: 6	676: Succulent steppe; Samphire	1.8% (Restricted)	High
CA	*Acacia aneura/aptaneura* sparse low woodland, over *Acacia burkittii* open tall shrubland*, over Eremophila galeata*, *Eremophila compacta, Senna sp. Meekatharra (E. Bailey 1-26), Senna artemisioides and Sida ectogama* sparse mid shrubland, over *Monachather paradoxus* open tussock grassland.	Extent: 34.6 ha Average species richness: 16 ± 4.5 Landform: Undulating plain and rocky hillslope Number of quadrats: 6	39: Shrublands; Mulga scrub	5.5% (Moderate)	Moderate: restricted to hill slopes
CB	*Acacia aneura/aptaneura* open low woodland, over *Acacia burkittii* and *Acacia tetragonophylla* sparse tall shrubland, over *Senna artemisioides x artemisioides*, *Senna glaucifolia* and *Eremophila galeata* open mid shrubland, over *Aristida contorta* open tussock grassland.	Extent: 6.6 ha Average species richness: 27.5 ± 2.1 Landform: Drainage line Number of quadrats: 2	39: Shrublands; Mulga scrub	5.5% (Moderate)	Moderate: restricted to drainage lines
CC	*Acacia pteraneura/macraneura* isolated low trees, over *Eremophila galeata, Senna artemisioides* and *Sida ectogama* sparse mid shrubland, over *Eragrostis eriopoda* and *Monachather paradoxus* open tussock grassland.	Extent: 122.2 ha Average species richness: 13.5 ± 4.1 Landform: Plain Number of quadrats: 13	39: Shrublands; Mulga scrub	5.5% (Moderate)	Low

Unit code	Vegetation unit description	Mapped extent, average species richness, landform and quadrats	Corresponding Beard Unit	% total area mapped in the Murchison* & (regional distribution)	Regional significance
CD	*Acacia aneura/aptaneura, Acacia pteraneura/macraneura* and *Acacia craspedocarpa* low woodland, over *Eremophila gilesii, Eremophila galeata* and *Senna artemisioides* sparse mid shrubland, over *Sida* sp. verrucose glands (F.H. Mollemans 2423), *Solanum lasiophyllum* and *Abutilon cryptopetalum* sparse low shrubland, over *Digitaria brownii, Eragrostis eriopoda* and *Monachather paradoxus* sparse tussock grassland.	Extent: 25.4 ha Average species richness: 19.1 ± 3.6 Landform: Plain, floodplain, drainage lines Number of quadrats: 8	18: Low woodland; Mulga (*Acacia aneura*)	59.9% (Widespread)	Low
			29: Sparse low woodland; Mulga, discontinuous in scattered groups	14.3% (Widespread)	
D	*Acacia aneura/aptaneura* and *Acacia ayersiana/caesaneura* open low woodland (+/-*Acacia tetragonophylla* and *Acacia pruinocarpa*), over *Eremophila forrestii, Eremophila latrobei, Eremophila foliosissima* sparse mid shrubland, over *Eragrostis eriopoda* sparse tussock grassland and *Triodia melvillei* sparse hummock grassland.	Extent: 9,226.8 ha Average species richness: 9.3 ± 2.7 Landform: Plain, floodplain, drainage lines Number of quadrats: 41	18: Low woodland; Mulga (*Acacia aneura*)	59.9% (Widespread)	Low
E	*Acacia aneura/aptaneura/ayersiana/caesaneura* (+/-*Eucalyptus gypsophila*) sparse low woodland, over *Acacia nyssophylla*, *Eremophila arachnoides* subsp. *arachnoides* and *Acacia victoriae* sparse mid to tall shrubland, over *Ptilotus obovatus, Sclerolaena obliquicuspis* and *Rhagodia eremaea* sparse low shrubland, over *Eragrostis eriopoda* sparse tussock grassland.	Extent: 630.3 ha Average species richness: 6.5 ± 3.4 Landform: Plain Number of quadrats: 17	560: Mosaic: Shrublands; Bowgada scrub/succulent steppe; Samphire	0.4% (Restricted)	High
F	+/- *Acacia victoriae* and/or *Melaleuca interioris* sparse tall shrubland, over *Eremophila glabra, Scaevola spinescens*, *Rhagodia eremaea* and *Lycium australe* sparse low shrubland.	Extent: 86.9 ha Average species richness: 6 ± 2.3 Landform: Plain Number of quadrats: 12	204: Succulent steppe with open scrub; scattered Mulga & *Acacia sclerosperma* over saltbush & bluebush	0.7% (Restricted)	High
G	*Acacia incurvaneura* woodland (+/-*Acacia craspedocarpa* and *Acacia ramulosa* var. *linophylla*), over *Eremophila maculata* and *Scaevola spinescens* shrubland over *Triodia melvillei* open hummock grassland.	Extent: 32.6 ha Average species richness: 6 ± 2.3 Landform: Plain Number of quadrats: 12	107: Hummock grasslands, shrub steppe; Mulga and *Eucalyptus kingsmillii* over hard spinifex	13.5% (Widespread)	Low

Unit code	Vegetation unit description	Mapped extent, average species richness, landform and quadrats	Corresponding Beard Unit	% total area mapped in the Murchison* & (regional distribution)	Regional significance
H	+/- *Eucalyptus striaticalyx* and *Acacia aneura/aptaneura* sparse low woodland, over *Eremophila glabra* and *Senna artemisioides* sparse mid shrubland, over *Dissocarpus paradoxus, Eremophila oppositifolia* and *Sclerolaena bicornis* sparse low shrubland.	Extent: 6.2 ha Average species richness: 5.8 ± 1.9 Landform: Plain Number of quadrats: 4	204: Succulent steppe with open scrub; scattered Mulga & *Acacia sclerosperma* over saltbush & bluebush	0.7% (Restricted)	High
I	+/- *Acacia aneura/aptaneura* isolated low trees, over *Lycium australe, Rhagodia drummondii*, *Frankenia pauciflora* sens. lat. and *Lawrencia squamata* open low shrubland.	Extent: 1,121.0 ha Average species richness: 5.7 ± 2.9 Landform: Plain, floodplain Number of quadrats: 4	676: Succulent steppe; Samphire	1.8% (Restricted)	Moderate: potentially restricted to near salt lakes
J	+/- *Casuarina pauper* sparse low woodland, over *Atriplex bunburyana, Lycium australe, Lawrencia squamata* and *Ptilotus obovatus* sparse low to mid shrubland, over *Eragrostis setifolia* sparse tussock grassland.	Extent: 548.5 ha Average species richness: 9.7 ± 2.5 Landform: Plain, floodplain, near salt lakes Number of quadrats: 15	676: Succulent steppe; Samphire	1.8% (Restricted)	Moderate: potentially restricted to near salt lakes
K	*Casuarina obesa* open low woodland, over *Acacia nyssophylla* sparse tall shrubland, over *Lycium australe* and *Sclerolaena fimbriolata* sparse low shrubland.	Extent: 19.7 ha Average species richness: 5.3 ± 0.6 Landform: Plain Number of quadrats: 3	676: Succulent steppe; Samphire	1.8% (Restricted)	Moderate: potentially restricted to near salt lakes
L	+/- *Acacia aneura/aptaneura* and *Hakea lorea* subsp. *lorea* isolated low trees, over *Alyogyne pinoniana, Androcalva loxophylla*, *Solanum coactiliferum* and *Leptosema chambersii* sparse low shrubland, over *Triodia basedowii* open hummock grassland and *Eragrostis eriopoda* sparse tussock grassland.	Extent: 283.4 ha Average species richness: 8 ± 3.6 Landform: Sandy plain Number of quadrats: 27	29: Sparse low woodland; Mulga, discontinuous in scattered groups	14.3% (Widespread)	Low
			107: Hummock grasslands, shrub steppe; Mulga and *Eucalyptus kingsmillii* over hard spinifex	13.5% (Widespread)	
M	*Acacia aneura/aptaneura* (+/-*Acacia ayersiana/caesaneura*) open low woodland, over *Eremophila forrestii, Eremophila spectabilis* subsp. *brevis* open mid shrubland, over *Triodia basedowii* open	Extent: 1,562.7 ha Average species richness: 12.8 ±	18: Low woodland; Mulga (*Acacia aneura*)	59.9% (Widespread)	Low
			29: Sparse low woodland; Mulga, discontinuous in scattered groups	14.3% (Widespread)	

Unit code	Vegetation unit description	Mapped extent, average species richness, landform and quadrats	Corresponding Beard Unit	% total area mapped in the Murchison* & (regional distribution)	Regional significance
	hummock grassland and *Eragrostis eriopoda* and *Monachather paradoxus* sparse tussock grassland.	3.5 Landform: Plain, sandy plain Number of quadrats: 37	107: Hummock grasslands, shrub steppe; Mulga and *Eucalyptus kingsmillii* over hard spinifex	13.5% (Widespread)	
N	*Acacia ayersiana/caesaneura* open low woodland (+/- *Acacia aneura/aptaneura* and *Eucalyptus eremicola* subsp. *peeneri*) open low woodland, over +/- *Melaleuca interioris* sparse tall shrubland, over *Triodia basedowii* open hummock grassland and *Eragrostis eriopoda* sparse tussock grassland.	Extent: 800.5 ha Average species richness: 14.7 ± 5.2 Landform: Plain, sandy plain Number of quadrats: 46	29: Sparse low woodland; Mulga, discontinuous in scattered groups	14.3% (Widespread)	Low
			204: Succulent steppe with open scrub; scattered Mulga & *Acacia sclerosperma* over saltbush & bluebush	0.9% (Restricted)	
			560: Mosaic: Shrublands; Bowgada scrub/succulent steppe; Samphire	0.4% (Restricted)	
			676: Succulent steppe; Samphire	1.8% (Restricted)	
O	*Acacia ayersiana/caesaneura* open low woodland (+/- *Eucalyptus eremicola* subsp. *peeneri*) open low woodland, over *Triodia melvillei* open hummock grassland.	Extent: 3,987.8 ha Average species richness: 9 ± 3 Landform: Plain, sandy plain Number of quadrats: 55	560: Mosaic: Shrublands; Bowgada scrub/succulent steppe; Samphire	0.4% (Restricted)	Low: also recorded at the borefields in other widespread units
P	+/- *Acacia ayersiana/caesaneura* (+/-*Eucalyptus eremicola* subsp. *peeneri* and *Eucalyptus kingsmillii)* sparse low woodland, over *Acacia ligulata* and *Acacia jamesiana* sparse mid shrubland, over *Halgania cyanea* sparse low shrubs, over *Triodia basedowii* open hummock grassland	Extent: 1,144.1 ha Average species richness: 11.6 ± 3.4 Landform: Plain, sandy plain Number of quadrats: 27	107: Hummock grasslands, shrub steppe; Mulga and *Eucalyptus kingsmillii* over hard spinifex	13.5% (Widespread)	Low
Q	*Callitris columellaris* sparse tall shrubland, over *Triodia melvillii* open hummock grassland.	Extent: 288.5 ha Average species richness: 5.4 ± 1.5 Landform: Plain, sandy plain Number of quadrats: 7	107: Hummock grasslands, shrub steppe; Mulga and *Eucalyptus kingsmillii* over hard spinifex	13.5% (Widespread)	Low

Unit code	Vegetation unit description	Mapped extent, average species richness, landform and quadrats	Corresponding Beard Unit	% total area mapped in the Murchison* & (regional distribution)	Regional significance
R	*Melaleuca xerophila* open tall shrubland, over *Muellerolimon salicorniaceum* sparse low shrubland, over *Eragrostis eriopoda* sparse tussock grassland.	Extent: 325.1 ha Average species richness: 5.4 ± 1.5 Landform: Plain, sandy plain Number of quadrats: 7	125: Bare areas; salt lakes	3.4% (Moderate)	High: restricted to the edges of salt lakes
S	*Tecticornia* spp., *Frankenia cinerea, Maireana villosa* and *Atriplex amnicola* sparse low shrubland.	Extent: 821.2 ha Average species richness: 4.2 ± 1.9 Landform: Salt lake, salt pan Number of quadrats: 24	125: Bare areas; salt lakes	3.4% (Moderate)	High: restricted to salt pans
			676: Succulent steppe; Samphire	1.8% (Restricted)	
T	*Tecticornia* spp., *Cratystylis subspinescens* and *Scaevola spinescens* sparse low shrubland.	Extent: 431.4 ha Average species richness: 2.1 ± 1.9 Landform: Salt lake, salt pan Number of quadrats: 11	125: Bare areas; salt lakes	3.4% (Moderate)	High: restricted to salt pans
U	*Tecticornia* spp., *Maireana amoena* and *Scaevola collaris* sparse low shrubland, over *Eragrostis lanipes* sparse tussock grassland.	Extent: 1,984.1 ha Average species richness: 4.2 ± 1.2 Landform: Salt lake, salt pan Number of quadrats: 11	125: Bare areas; salt lakes	3.4% (Moderate)	High: restricted to salt pans
V	*Tecticornia* spp., *Cratystylis subspinescens, Maireana amoena* and *Sclerolaena diacantha* sparse mid shrubland, over *Eragrostis falcata* sparse tussock grassland.	Extent: 324.0 ha Average species richness: 10.3 ± 3.6 Landform: Floodplain, salt pan, tributary Number of quadrats: 22	125: Bare areas; salt lakes	3.4% (Moderate)	Moderate: restricted to near salt pans
			204: Succulent steppe with open scrub; scattered Mulga & *Acacia sclerosperma* over saltbush & bluebush	0.9% (Restricted)	
			676: Succulent steppe; Samphire	1.8% (Restricted)	

Unit code	Vegetation unit description	Mapped extent, average species richness, landform and quadrats	Corresponding Beard Unit	% total area mapped in the Murchison* & (regional distribution)	Regional significance
W	*Eucalyptus striaticalyx* sparse low woodland, over *Grevillea sarissa* sparse tall shrubland, over *Lawrencia helmsii* sparse low shrubland.	Extent: 172.9 ha Average species richness: 5.6 ± 3.2 Landform: Floodplain, salt pan, tributary Number of quadrats: 8	125: Bare areas; salt lakes	3.4% (Moderate)	Moderate: restricted to edges of salt lakes on calcrete

*Notes: * Based on sum of all Beard vegetation units mapped for the Murchison*

Figure 9.5: PECs within 50 km of the Wiluna Uranium Project and its Extension

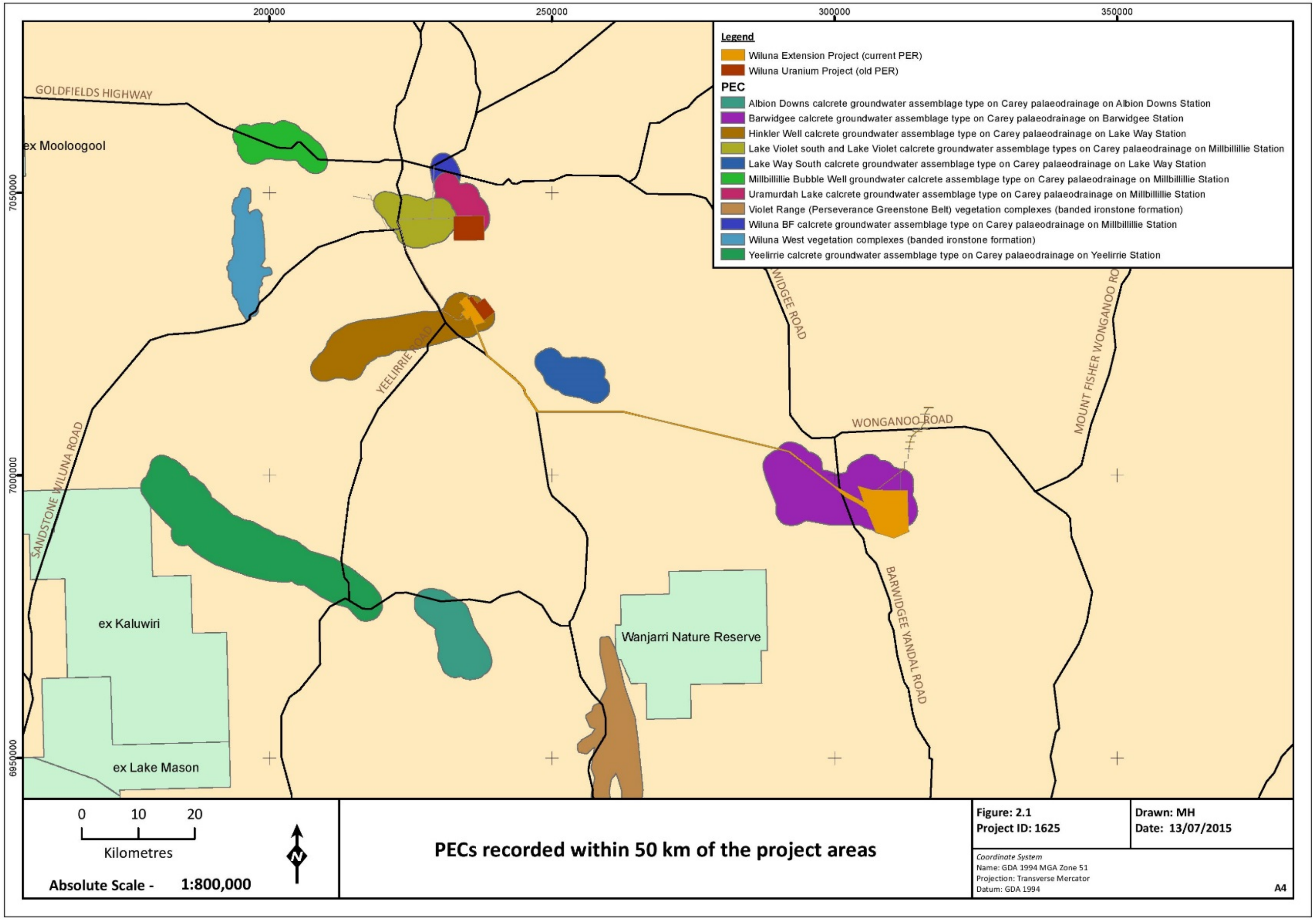


Table 9.7: Local conservation significance of vegetation units at the project areas

Unit	Vegetation description	Total area (ha)	Landform & potential local distribution of landform	Regional significance ^	Species richness #	Priority species	Assigned local significance
AA	*Acacia tetragonophylla* sparse tall shrubland, over *Senna artemisioides* and *Ptilotus obovatus* sparse low shrubland.	2,560.0	Plain: widespread	Low	8.8	*Eremophila arachnoides* subsp. *arachnoides*	Low
AB	*Acacia tetragonophylla, Acacia victoriae* and *Ptilotus obovatus* sparse low shrubland.	465.0	Plain: widespread	High	5.8	-	Moderate
AC	*Eucalyptus camaldulensis* subsp. *obtusa* sparse low woodland, over *Acacia aptaneura* and *Acacia tetragonophylla* sparse tall shrubland, over *Eremophila longifolia, Senna artemisioides* and *Scaevola spinescens* sparse mid shrubland.	3,009.2	Plain: widespread	High	10.5	*Stackhousia clementii*	Moderate
BA	*Acacia aneura/aptaneura* sparse low woodland, over *Acacia tetragonophylla* (+/- *Melaleuca hamata*) sparse tall shrubland, over *Senna artemisioides*, *Scaevola spinescens* and *Rhagodia drummondii* sparse mid shrubland, over *Ptilotus obovatus*, *Maireana villosa, Sclerolaena diacantha* and *Cratystylis subspinescens* sparse low shrubland.	92.3	Plain near salt lakes: moderately widespread	High	14.5	*Tecticornia cymbiformis*	Moderate
BB	*Casuarina pauper* open low woodland, over *Eremophila pantonii, Eremophila longifolia* and *Eremophila latrobei* sparse mid shrubland, over *Scaevola spinescens, Exocarpos aphyllus*, *Rhagodia drummondii* and *Ptilotus obovatus* sparse low shrubland.	1,105.6	Floodplain: moderate	High	15.7	*Cratystylis centralis*	Moderate
BC	*Scaevola spinescens, Eremophila malacoides, Rhagodia drummondii, Maireana villosa* and *Eremophila glabra* sparse low shrubland, over *Enteropogon ramosus* sparse tussock grassland.	59.7	Plain: widespread	Low	11.3	-	Low
BD	*Acacia aneura/aptaneura* sparse low woodland, over *Maireana pyramidata, Maireana triptera* and *Atriplex bunburyana* open low shrubland.	180.3	Plain: widespread	High	10.7	-	Moderate
CA	*Acacia aneura/aptaneura* sparse low woodland, over *Acacia burkittii* open tall shrubland*, over Eremophila galeata*, *Eremophila compacta, Senna sp. Meekatharra (E. Bailey 1-26), Senna artemisioides* and *Sida ectogama* sparse mid shrubland, over *Monachather paradoxus* open tussock grassland.	34.6	Undulating plain, rocky hillslope: restricted	Moderate	16	-	Moderate
CB	*Acacia aneura/aptaneura* open low woodland, over *Acacia burkittii* and *Acacia tetragonophylla* sparse tall shrubland, over *Senna artemisioides x artemisioides*, *Senna glaucifolia* and *Eremophila galeata* open mid shrubland, over *Aristida contorta* open tussock grassland.	6.6	Drainage line: restricted	Moderate	27.5	-	Moderate

Unit	Vegetation description	Total area (ha)	Landform & potential local distribution of landform	Regional significance ^	Species richness #	Priority species	Assigned local significance
CC	*Acacia pteraneura/macraneura* isolated low trees, over *Eremophila galeata, Senna artemisioides* and *Sida ectogama* sparse mid shrubland, over *Eragrostis eriopoda* and *Monachather paradoxus* open tussock grassland.	122.2	Plain: widespread	Low	13.5	-	Low
CD	*Acacia aneura/aptaneura, Acacia pteraneura/macraneura* and *Acacia craspedocarpa* low woodland, over *Eremophila gilesii*, *Eremophila galeata* and *Senna artemisioides* sparse mid shrubland, over *Sida* sp. verrucose glands (F.H. Mollemans 2423), *Solanum lasiophyllum* and *Abutilon cryptopetalum* sparse low shrubland, over *Digitaria brownii, Eragrostis eriopoda* and *Monachather paradoxus* sparse tussock grassland.	25.4	Plain, floodplain, drainage line: widespread	Low	19.1	-	Low
D	*Acacia aneura/aptaneura/ayersiana/caesaneura* open low woodland (+/-*Acacia tetragonophylla* and *Acacia pruinocarpa*), over *Eremophila forrestii, Eremophila latrobei, Eremophila foliosissima* sparse mid shrubland, over *Eragrostis eriopoda* sparse tussock grassland and *Triodia melvillei* sparse hummock grassland.	9,226.8	Plain: widespread	Low	9.3	*Eremophila pungens*	Low
E	*Acacia aneura/aptaneura/ayersiana/caesaneura* (+/-*Eucalyptus gypsophila*) sparse low woodland, over *Acacia nyssophylla*, *Eremophila arachnoides* subsp. *arachnoides* and *Acacia victoriae* sparse mid to tall shrubland, over *Ptilotus obovatus, Sclerolaena obliquicuspis* and *Rhagodia eremaea* sparse low shrubland, over *Eragrostis eriopoda* sparse tussock grassland.	630.3	Plain: widespread	High	6.5	*Eremophila arachnoides* subsp. *arachnoides*	Low
F	+/- *Acacia victoriae* and/or *Melaleuca interioris* sparse tall shrubland, over *Eremophila glabra, Scaevola spinescens*, *Rhagodia eremaea* and *Lycium australe* sparse low shrubland.	86.9	Plain: widespread	High	2.3	-	Moderate
G	*Acacia incurvaneura* woodland (+/-*Acacia craspedocarpa* and *Acacia ramulosa* var. *linophylla*), over *Eremophila maculata* and *Scaevola spinescens* shrubland over *Triodia melvillei* open hummock grassland.	32.6	Plain: widespread	Low	6	-	Low
H	+/- *Eucalyptus striaticalyx* and *Acacia aneura/aptaneura* sparse low woodland, over *Eremophila glabra* and *Senna artemisioides* sparse mid shrubland, over *Dissocarpus paradoxus, Eremophila oppositifolia* and *Sclerolaena bicornis* sparse low shrubland.	6.2	Plain: widespread	High	6.2	-	Moderate
I	+/- *Acacia aneura/aptaneura* isolated low trees, over *Lycium australe, Rhagodia drummondii, Frankenia pauciflora* sens. lat. and *Lawrencia squamata* open low shrubland.	1,121.0	Plain and floodplain: widespread	Moderate	5.7	-	Low

Unit	Vegetation description	Total area (ha)	Landform & potential local distribution of landform	Regional significance ^	Species richness #	Priority species	Assigned local significance
J	+/- *Casuarina pauper* sparse low woodland, over *Atriplex bunburyana, Lycium australe, Lawrencia squamata* and *Ptilotus obovatus* sparse low to mid shrubland, over *Eragrostis setifolia* sparse tussock grassland.	548.5	Plain and floodplain: moderately widespread	Moderate	9.7	*Eremophila arachnoides* subsp. *arachnoides*	Moderate
K	*Casuarina obesa* open low woodland, over *Acacia nyssophylla* sparse tall shrubland, over *Lycium australe* and *Sclerolaena fimbriolata* sparse low shrubland.	19.7	Plain and floodplain: moderately widespread	Moderate	19.7	-	Moderate
L	+/- *Acacia aneura/aptaneura* and *Hakea lorea* subsp. *lorea* isolated low trees, over *Alyogyne pinoniana, Androcalva loxophylla, Solanum coactiliferum* and *Leptosema chambersii* sparse low shrubland, over *Triodia basedowii* open hummock grassland and *Eragrostis eriopoda* sparse tussock grassland.	283.4	Sandy plain: widespread	Low	8	-	Low
M	*Acacia aneura/aptaneura* (+/-*Acacia ayersiana/ caesaneura*) open low woodland, over *Eremophila forrestii, Eremophila spectabilis* subsp. *brevis* open mid shrubland, over *Triodia basedowii* open hummock grassland and *Eragrostis eriopoda* and *Monachather paradoxus* sparse tussock grassland.	1,562.7	Sandy plain: widespread	Low	12.8	*Eremophila pungens*	Low
N	*Acacia ayersiana/caesaneura* open low woodland (+/-*Acacia aneura/aptaneura* and *Eucalyptus eremicola* subsp. *peeneri*) open low woodland, over +/- *Melaleuca interioris* sparse tall shrubland, over *Triodia basedowii* open hummock grassland and *Eragrostis eriopoda* sparse tussock grassland.	800.5	Sandy plain: widespread	Low	14.7	*Eremophila arachnoides* subsp. *arachnoides*	Low
O	*Acacia ayersiana/caesaneura* open low woodland (+/- *Eucalyptus eremicola* subsp. *peeneri*) open low woodland, over *Triodia melvillei* open hummock grassland.	3,987.8	Sandy plain: widespread	Low	9	*Eremophila arachnoides* subsp. *arachnoides* *Eremophila pungens*	Low
P	+/- *Acacia ayersiana/caesaneura* (+/-*Eucalyptus eremicola* subsp. *peeneri* and *Eucalyptus kingsmillii)* sparse low woodland, over *Acacia ligulata* and *Acacia jamesiana* sparse mid shrubland, over *Halgania cyanea* sparse low shrubs, over *Triodia basedowii* open hummock grassland.	1,144.1	Sandy plain: widespread	Low	11.6	-	Low
Q	*Callitris columellaris* sparse tall shrubland, over *Triodia melvillii* open hummock grassland.	288.5	Sandy plain: widespread	Low	5.4	-	Low
R	*Melaleuca xerophila* open tall shrubland, over *Muellerolimon salicorniaceum* sparse low shrubland, over *Eragrostis eriopoda* sparse tussock grassland.	325.1	Fringing salt lakes: restricted	High	5.4	-	High

Unit	Vegetation description	Total area (ha)	Landform & potential local distribution of landform	Regional significance ^	Species richness #	Priority species	Assigned local significance
S	*Tecticornia* spp., *Frankenia cinerea, Maireana villosa* and *Atriplex amnicola* sparse low shrubland.	821.2	Salt pan: restricted	High	4.2	*Frankenia confusa* *Tecticornia cymbiformis*	High
T	*Tecticornia* spp., *Cratystylis subspinescens* and *Scaevola spinescens* sparse low shrubland.	431.4	Salt pan: restricted	High	2.1	-	High
U	*Tecticornia* spp., *Maireana amoena* and *Scaevola collaris* sparse low shrubland, over *Eragrostis lanipes* sparse tussock grassland.	1,984.1	Salt pan: restricted	High	4.2	-	High
V	*Tecticornia* spp., *Cratystylis subspinescens, Maireana amoena* and *Sclerolaena diacantha* sparse mid shrubland, over *Eragrostis falcata* sparse tussock grassland.	324	Floodplain, salt pan: moderate	Moderate	10.3	*Frankenia confusa* *Stackhousia clementii* *Tecticornia cymbiformis*	Moderate
W	*Eucalyptus striaticalyx* sparse low woodland, over *Grevillea sarissa* sparse tall shrubland, over *Lawrencia helmsii* sparse low shrubland.	172.9	Fringing salt lakes: restricted	Moderate	5.6	-	Moderate

Notes: ^ Based on Table 5.1.

Vegetation units with a high local significance and which are equivalent to vegetation considered of potential significance in previous flora and vegetation assessments are discussed below. A cross reference to vegetation units identified as 'potentially significant' in earlier baseline studies is provided in Table 9.8. Those units correspond to the following units and descriptions:

AC: *Eucalyptus camaldulensis* subsp. *obtusa* sparse low woodland, over *Acacia aptaneura* and *Acacia tetragonophylla* sparse tall shrubland, over *Eremophila longifolia*, *Senna artemisioides* and *Scaevola spinescens* sparse mid shrubland, includes the Cr vegetation unit considered to be of potential significance in a previous flora and vegetation assessment (Niche 2011a – Appendix 10.12),

D: *Acacia aneura/aptaneura/ayersiana/caesaneura* open low woodland (+/-*Acacia tetragonophylla* and *Acacia pruinocarpa*), over *Eremophila forrestii*, *Eremophila* latrobei, *Eremophila foliosissima* sparse mid shrubland, over *Eragrostis eriopoda* sparse tussock grassland and *Triodia melvillei* sparse hummock grassland, includes the BIF and Sh complex vegetation units considered to be of potential significance in a previous flora and vegetation assessment (Niche 2011a – Appendix 10.12).

E: *Acacia aneura/aptaneura/ayersiana/caesaneura* (+/-*Eucalyptus gypsophila*) sparse low woodland, over *Acacia* nyssophylla, *Eremophila arachnoides* subsp. *arachnoides* and *Acacia* victoriae sparse mid to tall shrubland, over *Ptilotus obovatus*, *Sclerolaena obliquicuspis* and *Rhagodia eremaea* sparse low shrubland, over *Eragrostis eriopoda* sparse tussock grassland, includes the Ca1 vegetation unit considered to be of potential significance in previous flora and vegetation assessments (Niche 2011a – Appendix 10.12 and Niche 2014 – Appendix 10.13).

R: *Melaleuca xerophila* open tall shrubland, over *Muellerolimon salicorniaceum* sparse low shrubland, over *Eragrostis eriopoda* sparse tussock grassland is associated with beard unit 125, a restricted unit mapped as only 3.4% of the Murchison. This unit is also restricted to areas fringing salt lakes, which is even more restricted and is therefore given high local significance. Equivalent vegetation was also considered to be potentially significant in previous flora and vegetation assessments (Outback Ecology 2007a – Appendix 10.58; Niche 2011a – Appendix 10.12; and Actis 2012 – Appendix 10.61).

S: *Tecticornia* spp., *Frankenia cinerea*, *Maireana villosa* and *Atriplex amnicola* sparse low shrubland is associated with Beard vegetation units 676 and 125, both restricted units mapped as occurring across 1.8% and 3.4%, respectively of the Murchison. It is restricted to saline depressions, a very restricted landform and is also habitat for Priority flora including *Frankenia confusa* and *Tecticornia cymbiformis* and is therefore given high local significance. This vegetation unit also includes vegetation considered to be of potential significance in previous flora and vegetation assessments (Outback Ecology 2007a – Appendix 10.58; Niche 2011a – Appendix 10.12; Actis 2012 – Appendix 10.61 and Niche 2014 – Appendix 10.13).

T: *Tecticornia* spp., *Cratystylis subspinescens* and *Scaevola spinescens* sparse low shrubland is associated with Beard unit 125, a restricted unit mapped as only 3.4% of the Murchison. This unit is restricted to salt lakes and is therefore given high local significance. This vegetation unit also includes vegetation considered to be of potential significance in previous flora and vegetation assessments (Outback Ecology 2007a – Appendix 10.58; Niche 2011a – Appendix 10.12; Actis 2012 – Appendix 10.61; and Niche 2014 – Appendix 10.13).

U: *Tecticornia* spp., *Maireana amoena* and *Scaevola collaris* sparse low shrubland, over *Eragrostis* lanipes sparse tussock grassland is associated with Beard unit 125, a restricted unit mapped as only 3.4% of the Murchison. This unit is restricted to salt lakes and is therefore given high local significance. This vegetation unit also includes vegetation considered to be of potential significance in previous flora and vegetation assessments (Outback Ecology 2007a – Appendix 10.58; Niche 2011a – Appendix 10.12; Actis 2012 – Appendix 10.61; and Niche 2014 – Appendix 10.13).

V: *Tecticornia* spp., *Cratystylis subspinescens, Maireana amoena* and *Sclerolaena diacantha* sparse mid shrubland, over *Eragrostis falcata* sparse tussock grassland is associated with Beard vegetation unit 676, a restricted unit mapped as occurring across 1.9% of the Murchison. It is restricted to saline depressions and floodplains, a very restricted landform. It is also habitat for Priority flora including *Frankenia confusa, Stackhousia clementii* and *Tecticornia cymbiformis* and is therefore given high local significance. This vegetation unit also includes vegetation considered to be of potential significance in previous flora and vegetation assessments (Outback Ecology 2007a – Appendix 10.58 and Actis 2012 – Appendix 10.61).

W: *Eucalyptus striaticalyx* sparse low woodland, over *Grevillea sarissa* sparse tall shrubland, over *Lawrencia helmsii* sparse low shrubland, is equivalent to the vegetation unit KRE considered to be of potential significance in a previous flora and vegetation assessment (Outback Ecology 2009b – Appendix 10.17).

Table 9.8: Comparison of significant vegetation from previous flora and vegetation assessments

Unit	Ecologia 2015g – Appendix 10.49 Vegetation description	Outback Ecology (2007a – Appendix 10.58)	Outback Ecology (2009b - Appendix 10.17)	Niche (2011a - Appendix 10.12)	Actis (2012 – Appendix 10.61)	Niche (2014 - Appendix 10.13)
AC	*Eucalyptus camaldulensis* subsp. *obtusa* sparse low woodland, over *Acacia aptaneura* and *Acacia tetragonophylla* sparse tall shrubland, over *Eremophila longifolia, Senna artemisioides* and *Scaevola spinescens* sparse mid shrubland.	-	-	Cr	-	-
D	*Acacia aneura/aptaneura/ayersiana/caesaneura* open low woodland (+/- *Acacia tetragonophylla* and *Acacia pruinocarpa*), over *Eremophila forrestii, Eremophila latrobei, Eremophila foliosissima* sparse mid shrubland, over *Eragrostis eriopoda* sparse tussock grassland and *Triodia melvillei* sparse hummock grassland.	-	-	BIF/ Sh complex	-	-
E	*Acacia aneura/aptaneura/ayersiana/caesaneura* (+/-*Eucalyptus gypsophila*) sparse low woodland, over *Acacia nyssophylla*, *Eremophila arachnoides* subsp. *arachnoides* and *Acacia victoriae* sparse mid to tall shrubland, over *Ptilotus obovatus, Sclerolaena obliquicuspis* and *Rhagodia eremaea* sparse low shrubland, over *Eragrostis eriopoda* sparse tussock grassland.	-	-	Ca1	-	Ca1
R	*Melaleuca xerophila* open tall shrubland, over *Muellerolimon salicorniaceum* sparse low shrubland, over *Eragrostis eriopoda* sparse tussock grassland.	Me1	-	Fr1	Fr1	-
S	*Tecticornia* spp., *Frankenia cinerea, Maireana villosa* and *Atriplex amnicola* sparse low shrubland.	Halophytic vegetation	-	Sl1	Sl1	Sl
T	*Tecticornia* spp., *Cratystylis subspinescens* and *Scaevola spinescens* sparse low shrubland.		-			
U	*Tecticornia* spp., *Maireana amoena* and *Scaevola collaris* sparse low shrubland, over *Eragrostis lanipes* sparse tussock grassland.		-			
V	*Tecticornia* spp., *Cratystylis subspinescens, Maireana amoena* and *Sclerolaena diacantha* sparse mid shrubland, over *Eragrostis falcata* sparse tussock grassland.		-		Cp2	-
W	*Eucalyptus striaticalyx* sparse low woodland, over *Grevillea sarissa* sparse tall shrubland, over *Lawrencia helmsii* sparse low shrubland.	-	KRE	-	-	-

Key Findings of Baseline Surveys

The preceding discussion of vegetation in the Project area has provided a synthesis of relevant information, including studies conducted specifically for the Wiluna Unranium Project and its Extension and other relevant information from public sources. In order to consolidate and compare information from a wide range of sources, the following subsections present key findings of studies carried out for the main elements of the Extension to the Wiluna Project. The terminology used in the source technical reports is retained, in preference to the more general vegetation units adopted for the consolidated, whole-of-project assessment. These subsections are provided as a convenience to the reader. References to individual technical reports, which are appended to the PER, are provided throughout. Table 9.8 provides a cross reference to the vegetation descriptions used by individual technical assessors and the terminology adopted by Toro in its consolidated assessment of Project impacts on flora and vegetation.

Millipede

The eastern boundary of the Millipede development envelope abuts the western edge of the previously assessed Centipede development envelope (refer Niche Environmental Services (2011a – Appendix 10.12) for mapping and descriptions), while the northern boundary terminates on the salt lake. The southern and western boundaries are contiguous with native vegetation not likely to be impacted by any of the activities proposed by Toro.

No matters were noted in the EPBC Act Protected Matters Database search that related to the areas surveyed. No TECs as defined by DPaW were identified.

Five zones of vegetation have been defined at Millipede:

- *Tecticornia* spp. vegetation on the playa;
- Fringing vegetation, which was distributed as a belt along the interzone between the playa and the dune system;
- A dune system, comprising a foredune of *Acacia* species over spinifex and a rear dune system comprising *Acacia* species and mallee eucalypts over spinifex;
- Claypans hosting a mix of halophytic vegetation; and
- A calcrete platform which hosts vegetation dominated by *Acacia* species.

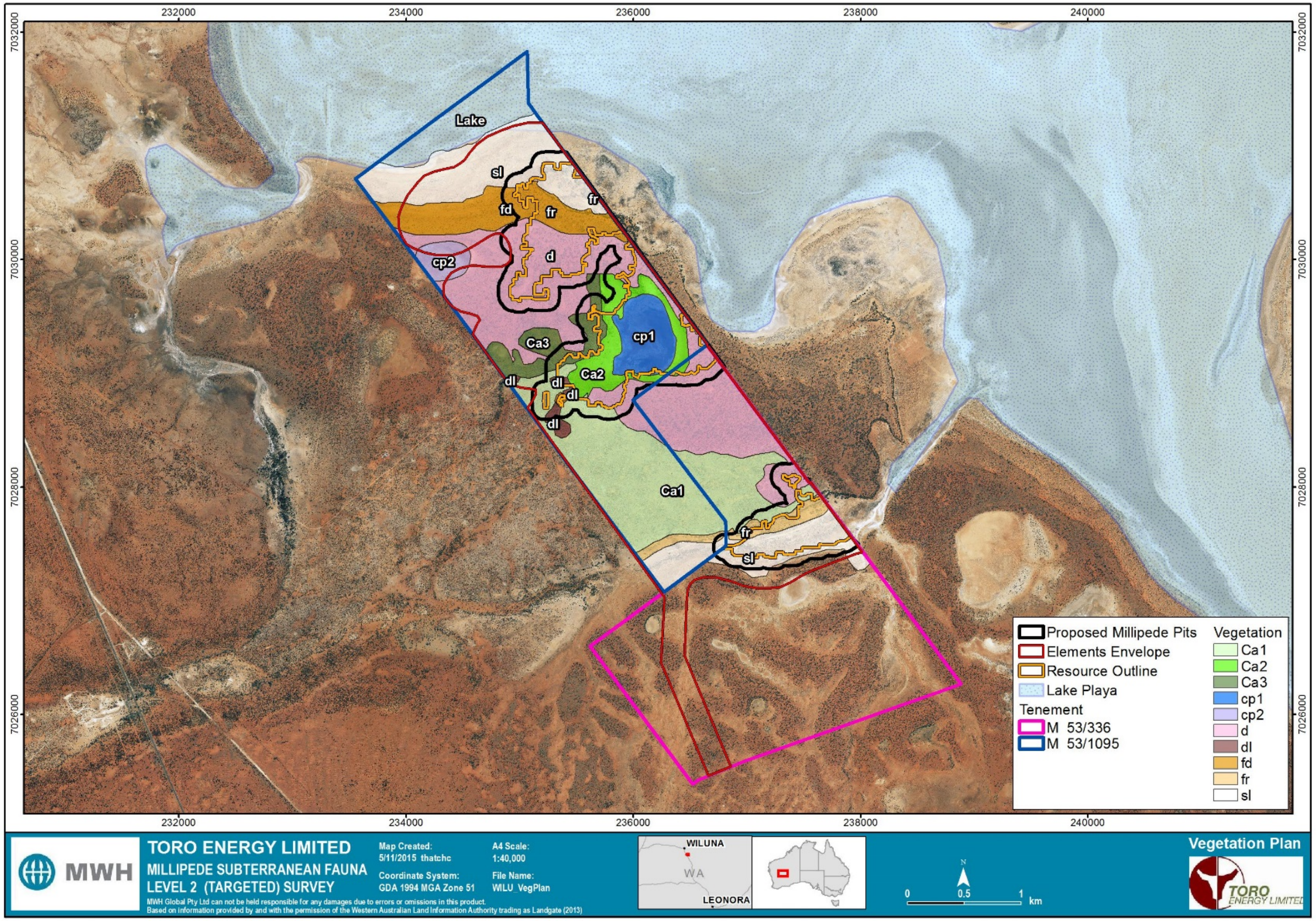
A total of 10 vegetation units were described and delineated (Figure 9.6):

- Playa;
- Fringing;
- Dune;
- Foredune;
- Low Woodland B of *Acacia* on calcrete;
- Open scrub of mixed species on calcrete;
- caOLWAcspp on calcrete;
- Low Woodland of *Acacia* on calcrete*;*
- Clay pan – halophytic species in soils of white red clay; and
- Clay pan – halophytic vegetation growing on red clays.

(Note: in Figure 9.6 the salt lake is identified as a vegetation unit. However, since the lake is not vegetated it is not considered to be a vegetation unit).

Playa vegetation occurs in the northern and southern parts of the Millipede survey area. The playa vegetation unit is characterised by the dominance of halophytic species, usually within the family Chenopodiaceae. Only one vegetation unit was identified on the playa and it was noted as being essentially mosaic, with subtle changes in species presence and density. Variations in species within the unit may relate to variability in the underlying hydrology.

Figure 9.6: Vegetation units Millipede



This playa vegetation unit was designated as “Low Heath D of *Tecticornia* species to 0.5 m with occasional pockets to 1 m”. The vegetation within the unit was generally uniform in height and density, with some changes in species composition noted across the surveyed area. The unit was located on the lake edge on heavy clays, light orange in colour with salt crusts in the north of the survey area, and on light orange clays in Abercromby Creek, located in the south of the survey area. There were pockets of *Lawrencia helmsii* in some areas, but these were not extensive enough to be mapped as separate units. The vegetation within the playa vegetation unit was assessed as being in good to very good condition although affected by exploration activity, with a number of tracks and drill lines located within the area. At the time of the survey, there was evidence of drought stress, although the scale of this will be affected by seasonal rainfall patterns.

The edge of the salt lake system is characterised by fringing vegetation which serves to demarcate the playa vegetation from the dune or calcrete vegetation. The vegetation exists as a narrow band located on the north and south of the survey area, immediately adjacent to the salt lake vegetation. This unit is typically about 10 m wide, although in some areas it is up to 30 m wide. Only one vegetation unit was mapped within the fringing vegetation zone. This unit was dominated by *Melaleuca xerophila* to 4 m, forming a closed forest. The unit was noted as generally being on orange to red sands, but occurs on light orange clays or calcrete in some areas. This unit is species poor, with few species contributing to the community structure. In some areas, *Muellerolimon salicorniaceum* was a dominant understorey species, while in other pockets *Tecticornia* species were noted. There were some instances where *Acacia ayersiana* was noted as a co-dominant species, but this was generally a reflection of intergrading, rather than characterising a sub-unit. The fringing vegetation unit was noted as being in good to very good condition. The vegetation had been affected by clearing for exploration and track development, but the impacts of this were limited in scale and extent.

Dune complexes are located between the playa and fringing vegetation and the calcrete platform. They occur on variable topography, with some sections characterised by a steep slope terminating in a high, narrow peak, while other areas of dune complex vegetation occur on gentler slopes at lower elevevation. Within the dunes, there is a distinction between the foredune vegetation, which faces toward the salt lake, and the dune vegetation, which faces toward the calcrete platform. One vegetation unit was mapped on the foredune and one on the dune. This unit was described as ‘Low Woodland A of *Eucalyptus eremicola* subsp. *peeneri* and *Acacia ayersiana* to a height of 10 m on red sands in shallow dunes’. The unit contained *A. aneura* var. *aneura* and *Grevillea sarissa* subsp. *succincta* as the dominant midstorey species, typically growing to a maximum height of 3–4 m. The understorey was a mid-dense hummock of *Triodia melvillei*. The condition of this vegetation was assessed as being good to very good. There were a series of small claypans within this unit, but these were largely devoid of vegetation. There were a number of exploration tracks located within the unit and some evidence of grazing by cattle.

The calcrete platform was a major feature of the study area. It is located behind the dune systems. The platform is characterised by a shallow topsoil of orange to red clays (absent in some parts) ooverlying calcrete. The calcrete platform is essentially flat, with areas of very minor relief adjacent to dunes or near drainage lines. Four vegetation units were defined and delineated on the calcrete platform:

- Low Woodland B of *Acacia* species: This vegetation unit was defined as being a Low Woodland B of *Acacia* species, generally to a height of 3 m, with occasional individuals to 5 m. The vegetation contained *Acacia ayersiana*, *A. tetragonophylla*, *A. burkittii* and *Acacia aneura* var. *aneura*. The understorey contained *Rhagodia*? *drummondii*, *Eremophila longifolia* and the Priority Three species *E. arachnoides* subsp. *arachnoides*. The condition of this vegetation ranged from good to degraded.
- Open scrub of mixed species: The structure was heavily impacted, and in many areas was reduced to an understorey of *Eremophea spinosa*, *Sclerolaena* and *Maireana* species with

occasional *Acacia victoriae*, *Cratystylis spinescens* and *Maireana pyramidata* forming a sparse upperstorey. The vegetation in this unit was assessed as being in poor to degraded condition.

- A vegetation unit, caOLWAcspp, was located on shallow red clays over calcrete, with the thickness of the clays increasing as they approached the dune system and the calcrete became more exposed in areas adjacent to the calcrete platform. The vegetation in this unit was comprised of *Acacia aneura* and *A. ayersiana* to 5 m over a midstorey dominated by *A. tetragonophylla*, *Senna artemisioides* and *Eremophila arachnoides* subsp. *arachnoides*. The vegetation in this unit was assessed as being in good condition, with impacts due to the presence of access tracks and drill pads, as well as from grazing by cattle.
- Low Woodland of *Acacia* species on a shallow, ephemeral drainage line: This vegetation unit was defined by an overstorey to 8 m of *Pittosporum phylliraeoides*, *Acacia macranuera* and *A. tetragonophylla* over a comparatively dense mid- and understorey. While the density of vegetation increased in the drainage line, there were no substantial changes to species composition. The drainage line vegetation was noted as being in good to very good condition, with the main disturbances due to grazing by cattle and low levels of damage from vehicles.

Two vegetation types were noted, both being located in depressions in the topography. The first unit comprised halophytic species in soils of white red clay. Key species within this unit were *Tecticornia halocnemoides* subsp. *halocnemoides*, *T. indica* subsp. *leiostachya* and *T. pterygosperma* growing to 0.5 m, with very occasional *Senna artemisioides*. The second clay pan vegetation unit comprised halophytic vegetation growing on red clays, with *Tecticornia indica* subsp. *bidens* and *T. indica* subsp. *leiostachya* the dominant species. The vegetation in this unit was assessed as being in very good condition.

The vegetation unit ca1, the dominant vegetation unit on the calcrete platform at Millipede, was noted as being a habitat for the Priority Three species *Eremophila arachnoides* subsp. *arachnoides*.

Targeted searches for *Eremophila arachnoides* subsp. *arachnoides* were conducted during surveys for the Centipede assessment, the result of which was the identification of a substantial population of this species. Based on the numbers of E *arachnoides* subsp. *arachnoides* recorded in vegetation unit ca1, this vegetation unit could have conservation significance. At the same time, it was noted that substantial numbers of this species occur to the north of Lake Way and to the south of Lake King, with all records made on similar vegetation (Niche Environmental Services, 2011a – Appendix 10.12). Any assessment of the significance of this vegetation unit and associated impacts to this species should therefore be considered in the context of the regional populations.

Groundwater Dependent Vegetation

A groundwater dependent ecosystem (GDE) is an ecosystem that requires access to groundwater so that ecological structure and function can be maintained (Murray *et al*., 2006). The occurrence of Tecticornia communities in close association with playa, which is underlain by groundwater at shallow depth, was provisionally taken as evidence for groundwater dependency. At Millipede, the main forms of GDEs considered to be present were those defined by Eamus *et al*. (2006) as being either ecosystems dependent on surface expressions of groundwater or ecosystems dependent on subsurface groundwater. A summary of the criteria for determining groundwater dependence in vegetation is presented in Table 9.9.

Table 9.9: Criteria for determining groundwater dependence in vegetation

Surface Expression of Groundwater	Subsurface Expression of Groundwater
Does a river flow all year, or a wetland or swamp remain wet all year despite prolonged periods of zero rainfall? (that is, zero or very low rainfall)	Are roots able to reach the water table? If roots can reach a source of fresh water it is generally true that this water will be absorbed by the roots and transpired by the canopy.
Within an estuary, does the salinity drop below that of seawater in the absence of surface water inputs (e.g. tributaries or stormwater)?	During extended dry periods, does a significant proportion of the vegetation remain green and physiologically active? The green region might be using groundwater to maintain its physiological activity.
Does the volume of flow in a stream or river increase downstream in the absence of inflow from a tributary?	Are large changes in LAI apparent at some locations, but not others within a small geographical range? The area not showing a large change in LAI might be accessing groundwater while the area that does show large intra-annual changes in LAI is probably not.
Is groundwater discharged (e.g. a spring) to the surface for significant periods of time each year? If such a resource is present, some species present are likely to be adapted to be using it.	Is the vegetation associated with the surface discharge of groundwater different (in terms of species composition, phenological pattern, LAI or vegetation structure) from vegetation close by, but which is not associated (i.e. not accessing) with this groundwater?
Is the vegetation associated with the surface discharge of groundwater different (in terms of species composition, phenological pattern, LAI or vegetation structure) from vegetation nearby that is not associated with this groundwater?	For sites that are not receiving significant amounts of lateral surface and subsurface flows, is the annual rate of water use by the vegetation significantly larger than the annual rainfall at the site?
Is the annual rate of water use by the vegetation significantly larger than annual rainfall at the site, and the site is not a run-on site?	Are plant water relations (especially pre-dawn and midday water potentials and transpiration rates) indicative of less water stress (potentials closer to zero; transpiration rate larger) than vegetation located nearby but upslope? The best time to measure this is during rainless periods.
Are plant water relations (especially pre-dawn and midday water potentials and transpiration rates) indicative of less water stress (potentials close to zero; transpiration rate larger) than vegetation located nearby, but not accessing the groundwater discharged at the surface?	Are seasonal changes in groundwater depth larger than can be accounted for by the sum of lateral flows and percolation to depth (i.e. a significant discharge path for groundwater)?
Is occasional (or habitual) groundwater release at the surface associated with key developmental stages of the vegetation (such as flowering, germination, seedling establishment)?	
Can small (typically less than 20 mm per day) fluctuations in the depth to groundwater be seen in the aquifer with a diurnal periodicity?	

Source: Adapted from Eamus et al. (2006).
Note: LAI – Leaf Area Index.

The communities across Millipede which may be groundwater dependent are presented in Figure 9.7. The figure shows that vegetation which may be groundwater dependent exists in areas where access to groundwater is increased due to high water tables or depressions in the landscape.

The four potential groundwater dependent vegetation units mapped across Millipede by Niche were:

- Low Heath D of *Tecticornia* Species (CP1);
- Low Heath D of *Tecticornia* Species (CP2);
- Fringing Closed Low Forest of *Melaleuca xerophila* (FR); and
- Low Heath D of *Tecticornia* Species (Sl).

Figure 9.7: Groundwater dependent vegetation Millipede

Haul Road

The vegetation units across the study area are shown in Figure 9.8, Figure 9.9 and Figure 9.10. The figures show a 300 m wide corridor in which the haul road would be situated. The haul road development envelope is a 30 m polygon inside the proposed alignment. This is not shown on the maps due to scale. Along the haul road, the entire potential alignment has been surveyed to allow flexibility in the final placement of the road, so that priority species are avoided as much as practicable.

No TECs or vegetation units likely to be TECs were located in the area studied and therefore no vegetation unit of national significance were recorded. No TECs or vegetation units likely to be TECs were recorded.

A total of 12 floristic-based vegetation units were described and delineated within the study area (Ecologica 2015a – Appendix 10.36).

The most widespread vegetation unit was M: *Acacia aneura/apataneura* (+/-*Acacia ayersiana/caesaneura*) open low woodland, over *Eremophila forrestii, Eremophila spectabilis* subsp. *brevis* open mid shrubland, over *Triodia basedowii* open hummock grassland and *Eragrostis eriopoda* and *Monachather paradoxus* spare tussock grassland mapped as 59.4% of the study area, followed by P: +/-*Acacia ayersiana/caesaneura* (+/- *Eucalyptus eremicola* subsp. *peeneri* and *Eucalyptus kingsmillii*) sparse low woodland, over *Acacia ligulata* and *Acacia jamesiana* sparse mid shrubland, over *Halgania cyanea* sparse low shrubs, over *Triodia basedowii* open hummock grassland mapped as 17.7% of the study area. The remaining 10 units were all mapped as under 5% of the study area.

There has been very low disturbance to the condition of the vegetation in the study area, which is reflected in the assessment of vegetation condition in the surveyed quadrats. Of the surveyed quadrats, 38% were in excellent condition and 58% were in very good condition. The majority of the disturbances were from grazing cattle and other non-native animals. Weeds were present, but in low densities and numbers.

The majority of the study area has not been recently burnt, with 94% of quadrats assessed as having no evidence of fire or estimated to have been burnt more than five years before the field survey. Four quadrats were estimated to have been burnt two to five years ago and no quadrats showed signs of fire more recently than that.

Figure 9.8: Vegetation units – Haul Road (Map 1)

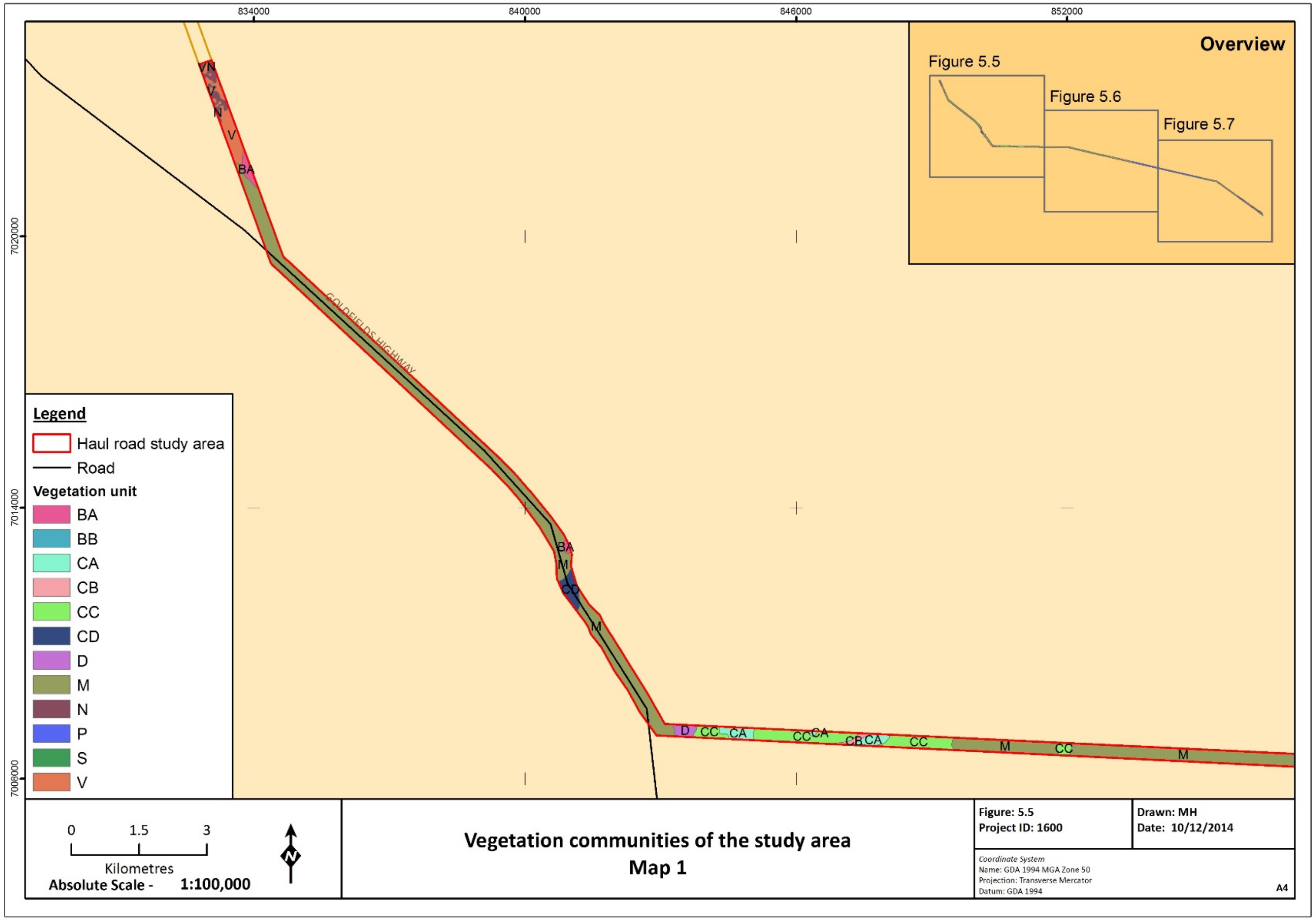


Figure 9.9: Vegetation units – Haul Road (Map 2)

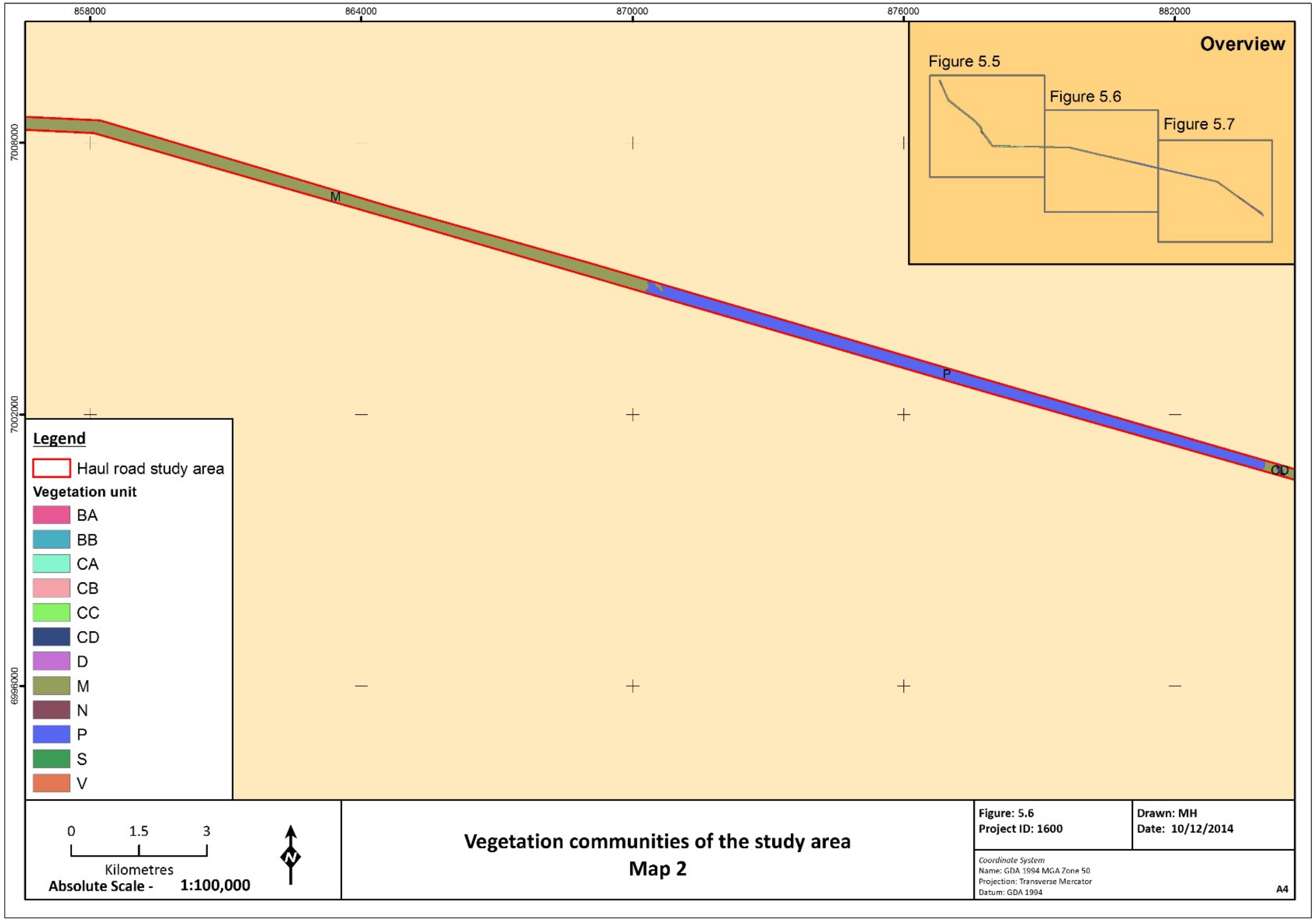
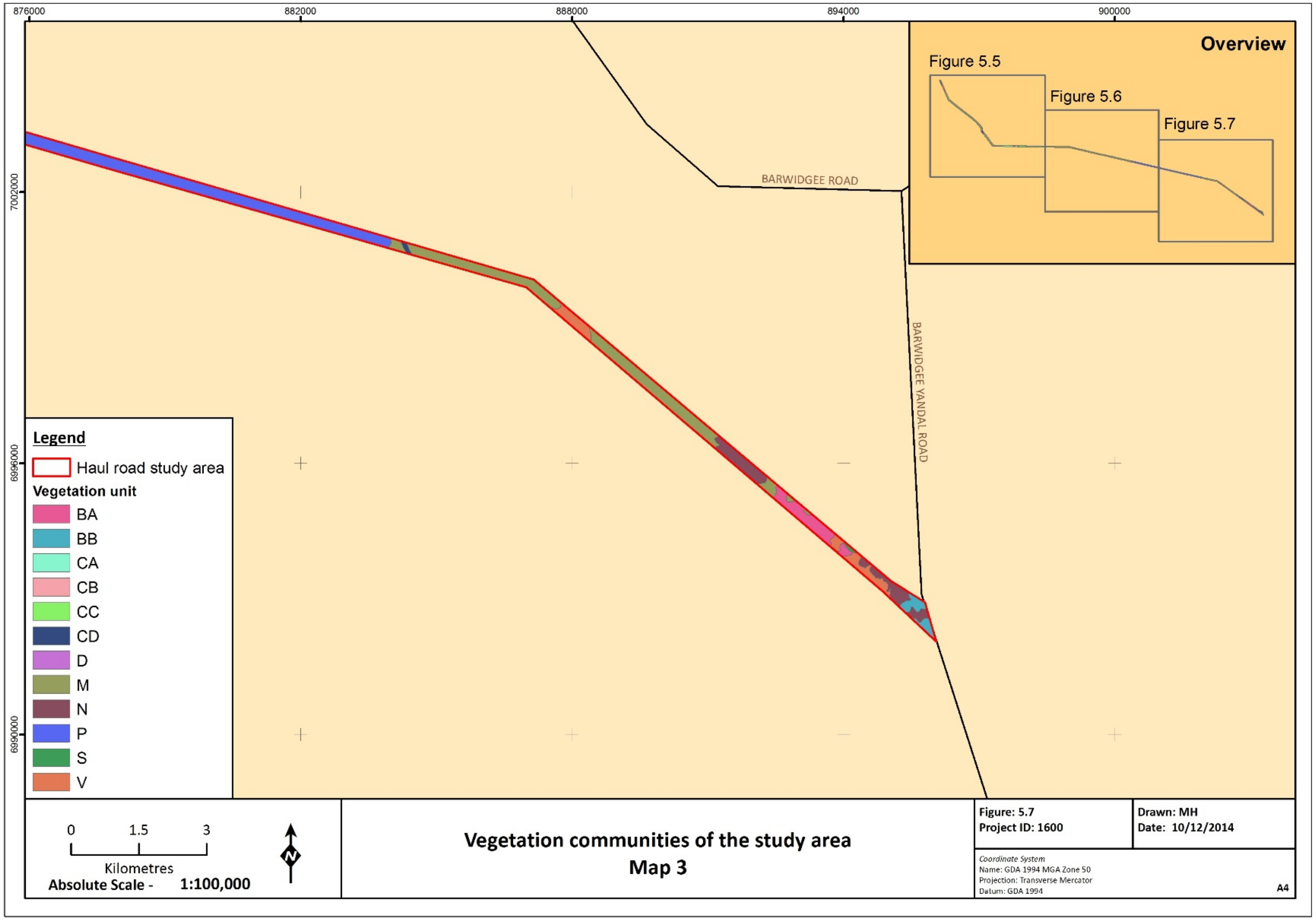


Figure 9.10: Vegetation units – Haul Road (Map 3)



Lake Maitland

A total of 31 vegetation communities have been identified and grouped into four associations: salt lake playa vegetation; kopi ridge vegetation; calcrete vegetation; and plains vegetation.
Three vegetation communities are described within the salt lake (playa) vegetation association: three within the kopi ridge vegetation; four within the calcrete vegetation; and 23 within the plains vegetation. Figure 9.11 shows the vegetation mapping at Lake Maitland.

The kopi ridge vegetation was the most restricted vegetation association identified in the Level 2 assessment. However, this vegetation unit was also found to occur elsewhere with its extent at Lake Maitland described by Outback Ecology (2009b – Appendix 10.17) as small.

The plains vegetation association demonstrates a high degree of variation, with 23 different vegetation communities. However, it was also observed that the majority of the species recorded in the plains were widespread throughout these communities. Five species recorded were noted to have restricted distributions: *Acacia aneura* var. cf. *major*, *A. brumalis*, *A. maxwellii*, *A. scleroclada* and *Sida kingii*.

Vegetation at the borefield, accommodation camp and within the access road corridor was divided into 11 broad vegetation formations, which were then further divided into 34 vegetation communities. Of these, the vegetation units comprising 'Calcrete platform vegetation' are potentially 'At Risk' in the Goldfields due to various threatening processes such as feral animals, grazing pressure and mining activities (Cowan, 2001; NLWRA, 2002). Approximately 400 ha of calcrete vegetation was mapped during the survey of the accommodation camp, access road and the southern portion of the access to the borefield. The eventual disturbance within these surveyed areas would be substantially less and a small fraction of the total area of the calcrete vegetation type (less than 20 sq km). Therefore, it is unlikely that these disturbances would have a significant impact on this habitat.

A large percentage of the Lake Maitland area hosts two mosaics and a successional vegetation unit (Fire Regeneration *Eucalyptus*), which is a consequence of sections of the plains vegetation having been subjected to fire within the last five years. The distribution of six of the 23 plains vegetation communities described was restricted to within the two plains mosaic communities. No Priority Ecological Communities or Threatened Ecological Communities occur in the Lake Maitland Project area (Outback Ecology, 2009b – Appendix 10.17).

Vegetation mapping at Lake Maitland was based on interpretations of aerial photography, quadrat data, field observations and statistical data. The boundaries of vegetation communities were identified on aerial photography for plotting, at a scale of 1:25,000. Aerial photography was used to interpolate vegetation communities across Lake Maitland. Vegetation communities were grouped into broad vegetation types, based on geomorphological and floristic similarities.

Figure 9.11: Lake Maitland vegetation mapping

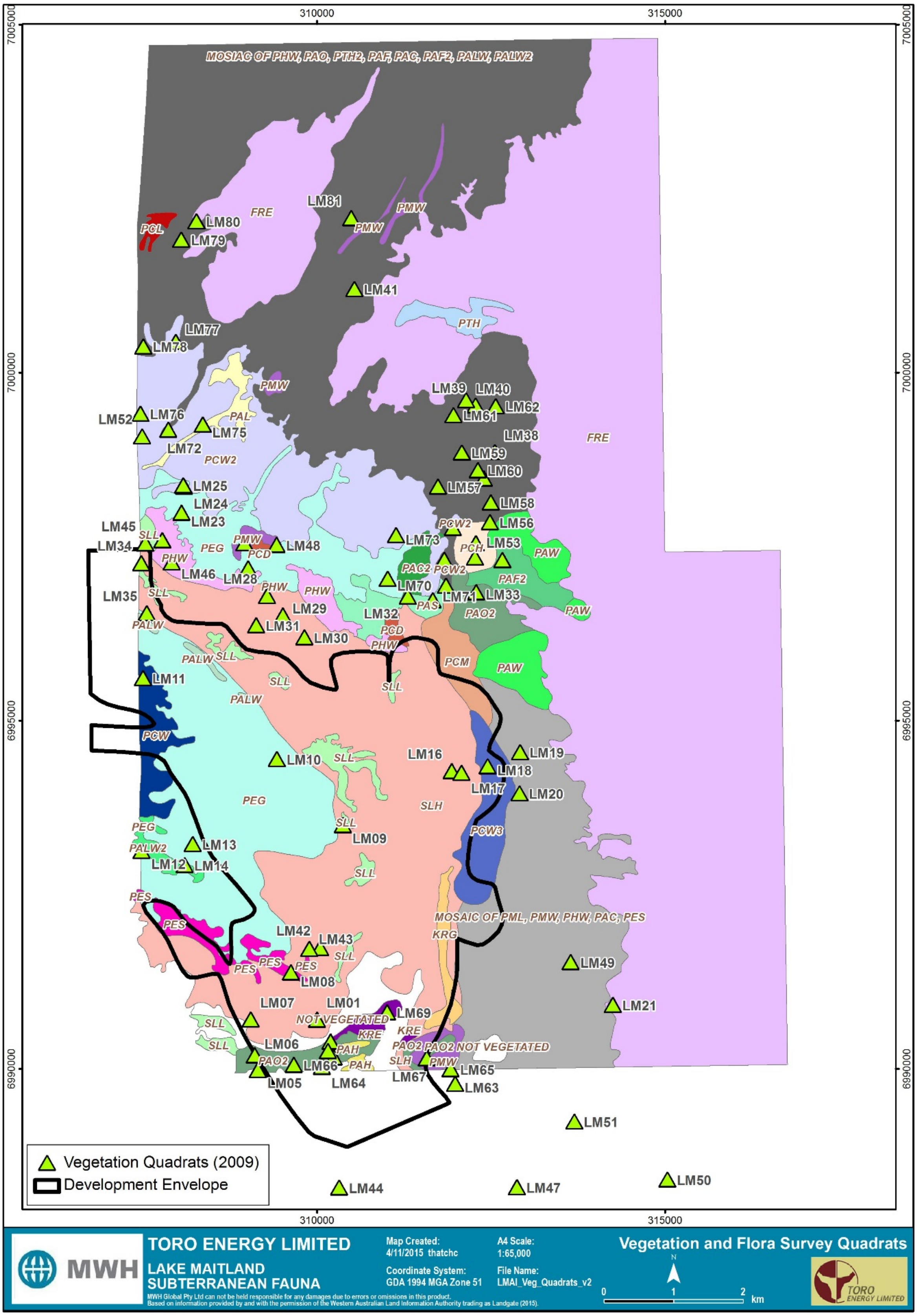


Figure 9.12: Lake Maitland vegetation mapping –legend to Figure 9.11

Post-fire Emergent Species in Fire Regeneration *Eucalyptus* Vegetation

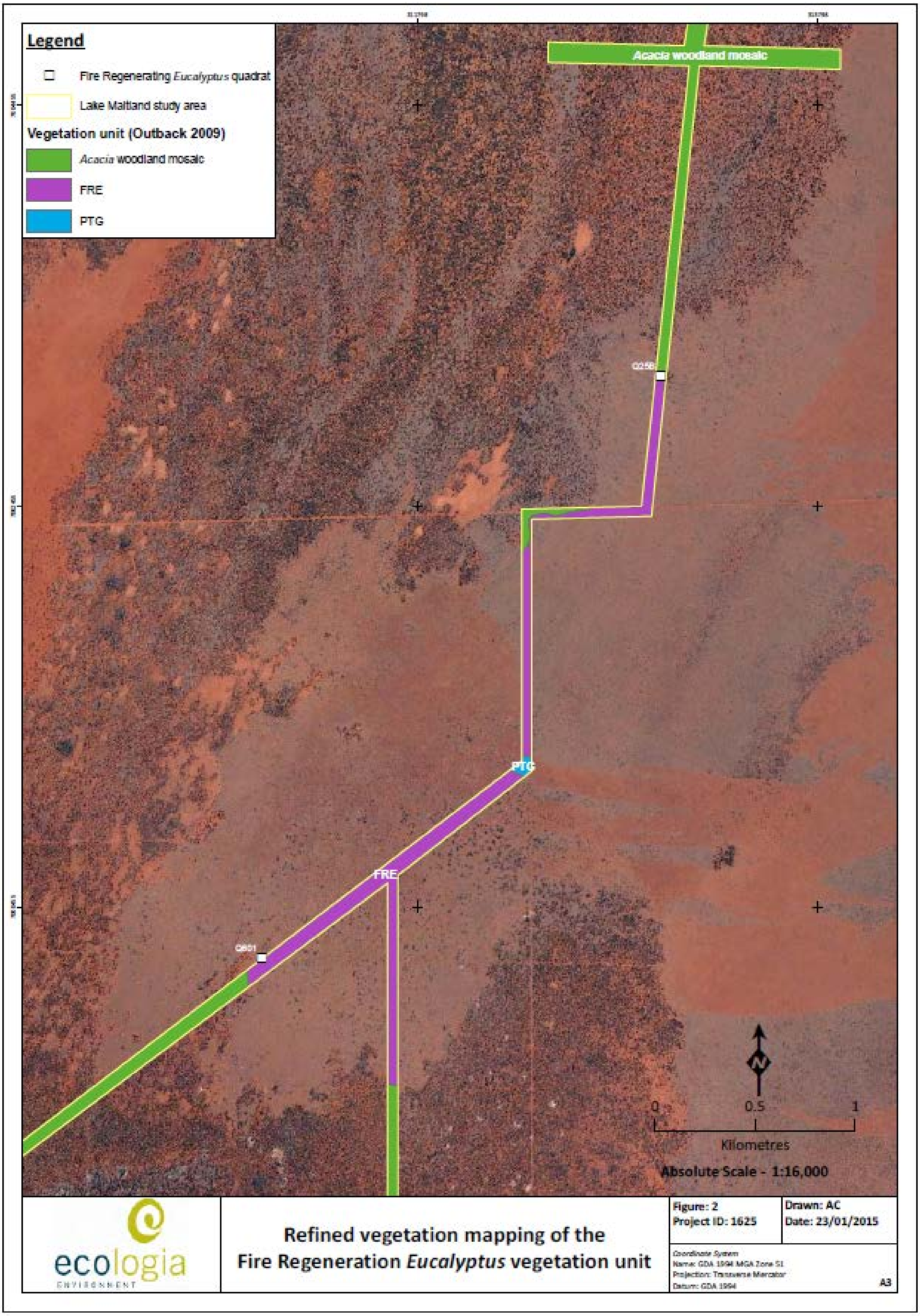
Toro commissioned Ecologia to undertake an assessment of potentially restricted post-fire emergent plant species within the Fire Regeneration *Eucalyptus* (FRE) vegetation unit mapped by Outback Ecology (2009b – Appendix 10.17), and also to refine the mapping boundaries of the FRE within the Lake Maitland study area. Ground truthing of these communities was undertaken at the request of the EPA (Ecologia, 2015d – Appendix 10.6).

In January 2015, 5.8 km of transects, predominantly across the location of the Lake Maitland borefield (Figure 9.13), were surveyed through the FRE vegetation unit previously mapped as Open Low Woodland of *Eucalyptus eremicola* subsp. *peeneri* over *Acacia sibina*, *Alyogyne pinoniana*, *Kennedia prorepens* and *Leptosema chambersii*, over very dense *Triodia basedowii* hummock grassland (Quadrats LM21 and LM85). Potentially restricted post-fire emergent species were targeted along these transects, in addition to any species not recorded during the 2009 survey.

Species were assessed as potentially post-fire emergent on the basis of their exclusive or near-exclusive presence within the FRE vegetation previously mapped. Species recorded from all the 2009 quadrats, as well as from 107 quadrats surveyed by Ecologia within the proposed mining area and access road corridor (located outside of the mapped FRE unit), were used for comparison (Figure 9.14).

Figure 9.13: Mapping of FRE vegetation units at proppsed borefield

Figure 9.14: Location of FRE quadrants and transects at proposed borefield at Lake Maitland



Along the transects and within FRE quadrats, eight species were assessed as potentially post-fire emergent species, or are known to be post-fire emergent species (e.g. *Leptosema chambersii*) (Crisp, 1999), having been recorded primarily or exclusively by Outback Ecology (2009b – Appendix 10.17) and/or Ecologia (2015d – Appendix 10.6) within the FRE vegetation unit and are detailed in Table 9.10. All of these species, however, are widespread (based on current Western Australian Herbarium records) and are not considered locally endemic or restricted.

Table 9.10: Potential post-fire emergent species recorded from the FRE unit

Species	Sites Recorded[1]	Sites Recorded[2]	WA Distribution (IBRA Region)[3]
Dicrastylis brunnea	T-EUC01, T-EUC03, Q25B, Q801	Not recorded	Widespread (COO, GAS, MUR)
Dicrastylis flexuosa	Q801	LM80 (non-FRE)	Widespread (COO, MUR)
Kennedia prorepens	T-EUC03	LM21 (FRE), LM50 (FRE)	Widespread (AVW, CER, COO, DAL, ESP, GAS, GES, GID, GSD, GVD, LSD, MAL, MUR, PIL, YAL)
Keraudrenia velutina	T-EUC03, T-EUC-04	Not recorded	Widespread (CAR, GAS, GVD, MUR, PIL)
Leptosema chambersii	T-EUC03, Q801, Q44	LM21 (FRE), LM50 (FRE)	Widespread (CER, COO, GAS, GID, GSD, GVD, LSD, MUR, PIL, TAN)
Swainsona microphylla	T-EUC03	LM50 (FRE), LM80 (non-FRE)	Widespread (CER, COO, GAS, GID, GSD, GVD, HAM, LSD, MUR, NUL, PIL)
Sida cardiophylla	Q801	Not Recorded	Widespread (CER, DAL, GAS, GID, GSD, GVD, LSD, MUR, PIL)
Scaevola parvifolia	Q801	Not recorded	Widespread (CAR, CER, COO, DAL, GAS, GID, GSD, GVD, LSD, OVP, PIL, TAN, YAL)

Source: 1. Ecologia (2015d – Appendix 10.6); 2. Outback Ecology (2009b – Appendix 10.17);
3. Distribution based on FloraBase records (accessed 23/1/2015) (Western Australian Herbarium 1998–2015).

Outback Ecology (2009b – Appendix 10.17) mapped a large portion of recently burned vegetation as the FRE vegetation unit. One quadrat surveyed by Ecologia (Q801) fell within the FRE unit mapped. This quadrat, although lacking *Eucalyptus*, otherwise contained several dominant species used to define the FRE unit, namely *Alyogyne pinoniana*, *Leptosema chambersii* and *Triodia basedowii*. Quadrat Q25B represented *Acacia* (mulga) woodland and, although bordering the FRE unit, fell within the mosaic of *Acacia* woodland vegetation previously mapped. Quadrat Q26B represented *Triodia basedowii* grassland. This portion of the Lake Maitland study area was not mapped in 2009. The vegetation units previously delineated that correspond to the three Ecologia quadrats are shown in Table 9.11. Based on this data, the vegetation unit boundaries within the study area were refined (Table 9.12).

Table 9.11: Ecologia quadrats and corresponding Outback Ecology 2009b – Appendix 10.17) vegetation Units

Ecologia Quadrat	Dominant Species	Corresponding Outback (2009b – Appendix 10.17) Vegetation Unit/s
Q25B	*Acacia ?aptaneura*, *Senna artemisioides* subsp. *filifolia*, *Triodia basedowii*	Plains *Acacia* Woodland 2 or Plains *Acacia* Open Low Woodland (PAW2/PAOW)
Q26B	*Hakea lorea* subsp. *lorea*, *Androcalva loxophylla*, *Triodia basedowii*	Plains *Triodia* grassland (PTG)
Q801	*Acacia pachyacra*, *Melaleuca eleuterostachya*, *Alyogyne pinoniana*, *Leptosema chambersii*, *Triodia basedowii*	Fire Regeneration *Eucalyptus* (FRE)

Table 9.12: Descriptions of vegetation units

Vegetation Unit	Description	Area (ha) within Lake Maitland Deposit Study Area
FRE	Open Low Woodland of *Eucalyptus eremicola* subsp. *peeneri* over *Acacia sibina*, *Alyogyne pinoniana*, *Kennedia prorepens* and *Leptosema chambersii*, over very dense *Triodia basedowii* hummock grassland.	29.05
PTG	Open Low Scrub of *Hakea lorea* subsp. *lorea* and *Hakea preissii* over *Ptilotus obovatus*, *Sclerolaena parviflora*, over *Triodia basedowii* and *Triodia desertorum* hummock grassland and open low grass *Aristida contorta*.	4.81
Acacia woodland mosaic[1]	Mosaic of PAF, PAF2, PALW, PALW2, PAOW, PAW2, PEW, PMW, PTH.	133.96[2]

Notes: 1. See Outback Ecology (2009b – Appendix 10.17) for vegetation descriptions.
2. Value corresponds to area of Acacia woodland mosaic within the study area refined by Ecologia and not the whole of the Lake Maitland study area.

Groundwater Dependent Vegetation

Vegetation communities 2 and 3 identified by the Level 2 survey at Lake Maitland were groundwater dependent ecosystems (GDEs), occurring within 1 km of areas to be disturbed for mining. Toro plans to construct barriers to restrict water influx to the mine pits and control groundwater drawdown outside the mining area. Toro would also conduct regular monitoring to ensure that groundwater dependent vegetation communities are not adversely impacted by the Proposal.

9.4.3 Flora

Priority Flora Overview

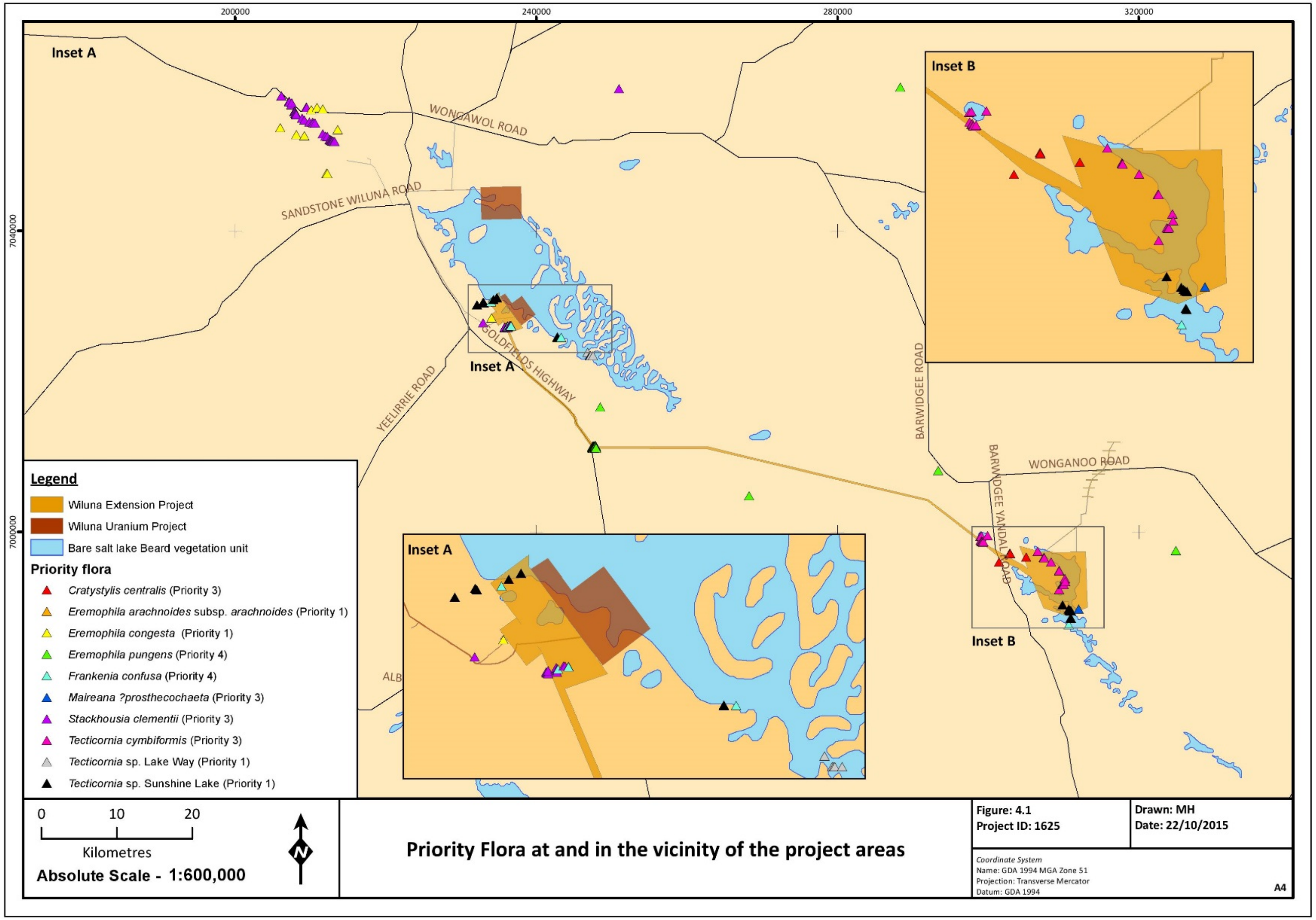
The Priority flora taxa identified from the flora and vegetation assessments included in this consolidation are listed in Table 9.13 and locations shown in Figure 9.15. Coordinates are provided electronically in Appendix A of Ecologia 2015g (Appendix 10.49 of the PER).

Table 9.13: Priority flora

Flora taxon	Reference	Location and population description
Eremophila arachnoides subsp. *arachnoides* (P3)	Niche (2011a - Appendix 10.12)	Three large populations were described. One population at Centipede deposit (5,440 individuals) one population north of Lake Way deposit (18,500 individuals) and one population approximately 100 km north of Wiluna (18,000 individuals).
	Niche (2014 - Appendix 10.13)	
Eremophila congesta (P1)	Niche (2011a - Appendix 10.12)	Recorded extensively throughout the West Creek Borefield and one location west of the Millipede deposit.
Tecticornia sp. Lake Way (P1)	Niche (2011a - Appendix 10.12)	Recorded from previously known location approximately 10 km to the south of the Centipede/millipede deposits at Lake Way.
	Actis (2012 - Appendix 10.61)	
	Ecologia (2015a – Appendix 10.36)	
Tecticornia sp. Sunshine Lake (P1)	Ecologia (2015e – Appendix 10.7)	Recorded commonly at both Lake Maitland and Lake Way.
Cratystylis centralis (P3)	Ecologia (2015e – Appendix 10.7)	Two locations to the west of the Lake Maitland deposit.
Homalocalyx echinulatus (P3)^	Niche (2011a - Appendix 10.12)	Recorded from the West Creek Borefield. No abundance details or locations available.
Maireana ?prosthecochaeta (P3)	Outback Ecology (2007a - Appendix 10.58)	One record in the south-east of Lake Maitland. A targeted search by *ecologia* (November 2014 and January 2015) of approximately 23 km in and around the location of the original record, and areas of similar habitat (*ecologia* 2015b) suggests that this was an identification error and unlikely to occur here.
Mirbelia stipitata (P3)^	Niche (2011a - Appendix 10.12)	Collected from adjacent to Gunbarrel Highway during the regional survey. Not recorded at the project areas.
Stackhousia clementii (P3)	Niche (2011a - Appendix 10.12)	Two populations were reported, one at the West Creek Borefield (114 individuals) and one west of the Centipede deposit/Millipede deposit (500-1,000 individuals).
	Niche (2014 - Appendix 10.13)	One population of between 500 and 1,000 individuals in a minor tributary in the south of the Millipede deposit.
	Ecologia (2015a – Appendix 10.36)	One location with 5 individuals recorded in a minor tributary in the south of the Millipede deposit.
Tecticornia cymbiformis (P3)	Actis (2012 - Appendix 10.61)	Recorded at one quadrat at Lake Maitland. No coordinates available, so has not been included.
	Ecologia (2015e – Appendix 10.7)	Substantial population (5,480 individuals) at Lake Maitland, including fringing the main lake bed and a small salt pan to the west of Lake Maitland (intercepting the Haul Road alignment).
	Ecologia (2015e - Appendix 10.7)	
Eremophila pungens (P4)	Ecologia (2015e – Appendix 10.7)	A substantial population of over 2,000 individuals was recorded from the Millipede to Lake Maitland haul road.
Frankenia confusa (P4)	Ecologia (2015e – Appendix 10.7)	Scattered individuals on edge of Lake Way and Lake Maitland.

Notes: ^ = no coordinates available

Figure 9.15: Priority Flora at the Wiluna Uranium Project and its Extension



Novel and Potentially Novel Flora Taxa Overview

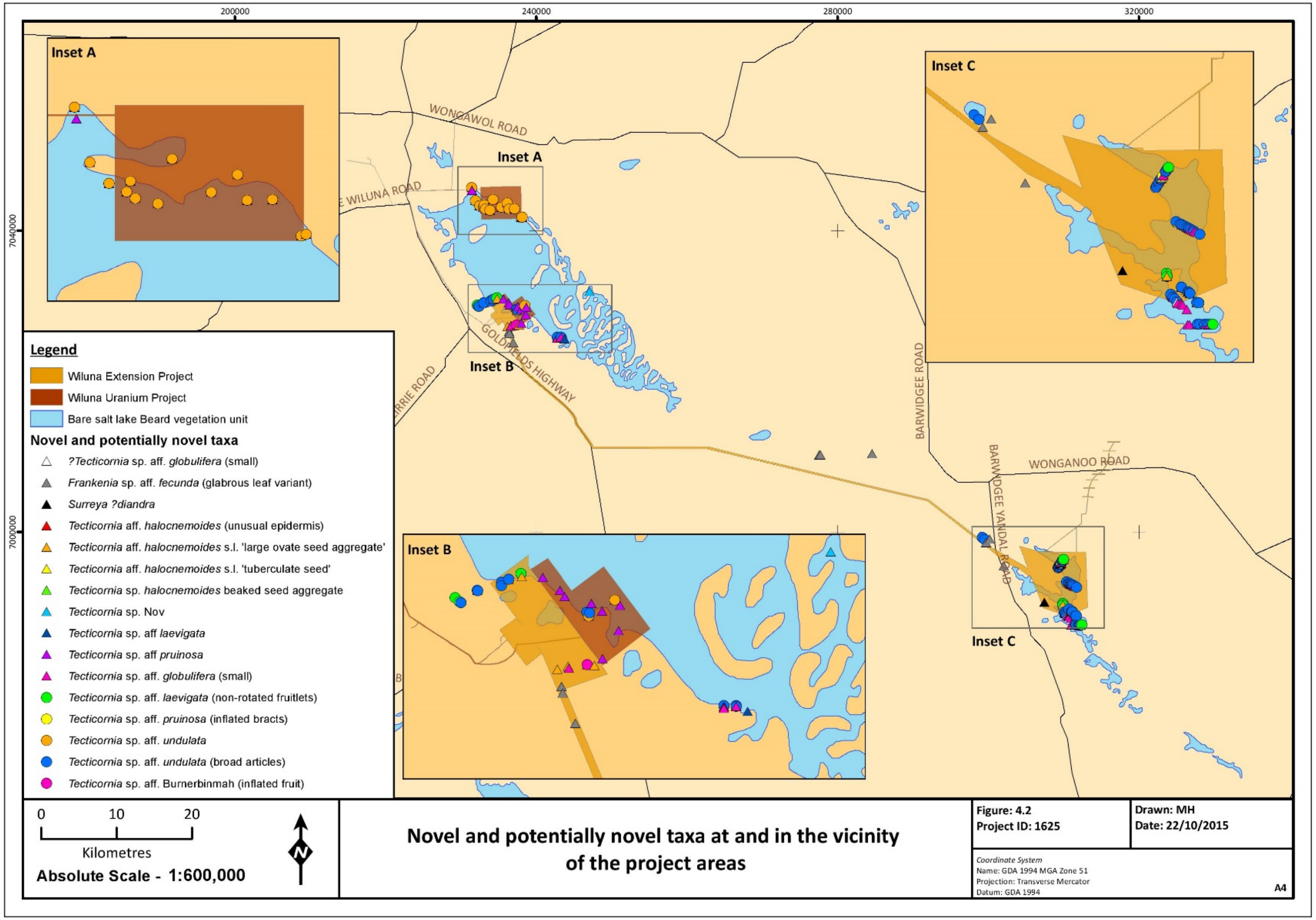
The potentially new flora taxa identified from the flora and vegetation assessments included in this consolidation are listed in Table 9.14 and locations shown in Figure 9.16. Coordinates are provided electronically in Appendix A of Ecologia 2015g (Appendix 10.49 of the PER).

Table 9.14: Potentially new flora taxa

Taxa	Location and population description
Novel taxa (Ecologia 2015e - Appendix 10.7)	
Tecticornia aff. *halocnemoides* s.l. 'large ovate seed aggregate'	Lake Way: Common on the edge of the main salt lake and minor tributary to the south of millipede/centipede. Lake Maitland: Common on the main lake bed and trail of small salt pans that run to the south.
Tecticornia aff. *halocnemoides* s.l. 'tuberculate seed'	Lake Maitland: Common on the main lake bed and trail of small salt pans that run to the south.
Tecticornia sp. aff. *globulifera* (small)	Lake Way: Very common on the edge of the main lake bed and minor tributaries. Lake Maitland: Very common on the main lake bed and on the trail of small salt pans to the south.
Tecticornia sp. aff. *laevigata* (non-rotated fruitlets)	Lake Way: Common on the main lake bed and minor tributaries. Lake Maitland: Common on the main lake bed and the small salt pan trail that runs south.
Tecticornia sp. aff. *pruinosa* (inflated bracts)	Lake Maitland: Scattered in the main lake bed.
Tecticornia sp. aff. Burnerbinmah (inflated fruit)	Lake Way: Recorded scattered on the minor tributary in the south of millipede.
Tecticornia sp. aff. *undulata* (broad articles)	Lake Way: Common on the main lake bed and minor tributaries. Lake Maitland: Very common on the main lake bed and on the trail of small salt pans to the south.
Potentially novel taxa (Ecologia 2015a - Appendix 10.36)	
Tecticornia aff. *halocnemoides* (unusual epidermis)	Lake Maitland: Scattered at one location in the trail of small salt pans that run to the south.
?Tecticornia sp. aff. *globulifera* (small)	Lake Way: Scattered on the main lake bed. Lake Maitland: Scattered on the trail of small salt pans that run to the south.
Frankenia sp. aff. *fecunda* (glabrous leaf variant)	Scattered at the southern end of Millipede and the haul road.
Surreya ?diandra	One location in the south-western section of the Millipede deposit.
Potentially novel taxa (Niche 2011a – Appendix 10.12)	
Tecticornia sp. *halocnemoides* beaked seed aggregate	Lake Way: Common on the main lake bed and the minor tributary running north from the Lake Way deposit.
Tecticornia sp. aff. *laevigata*	Lake Way: Common on the main lake bed of the centipede and millipede deposits and on the main tributary that runs north from the Lake Way deposit.
Tecticornia sp. aff. *pruinosa*	Lake Way: Very common on the main lake bed of the centipede/Millipede deposits and Lake Way deposits. Also recorded on the minor tributaries of both areas.
Tecticornia sp. aff. *undulata*	Lake Way: Very common on the main lake bed of the centipede/Millipede deposits and Lake Way deposits. Also recorded on the minor tributaries of the Lake Way deposit.
Frankenia ?interioris^	Recorded in the Centipede and Lake Way project areas.
Frankenia sp. cf. *glomerata*^	Recorded at the West Creek Borefield area.
Rhagodia drummondii sens. lat.^	Scattered in the Lake Way deposit and regionally neat Lake King.
Scaevola spinescens^	Common across Centipede and Lake Way deposits and the West Creek Borefield.
Tecticornia sp. nov	One location in a regional quadrat. No coordinates available.

Notes: ^ = no coordinates available

Figure 9.16: Novel and potentially novel taxa at and in the vicinity of the Wiluna Uranium Project and its Extension



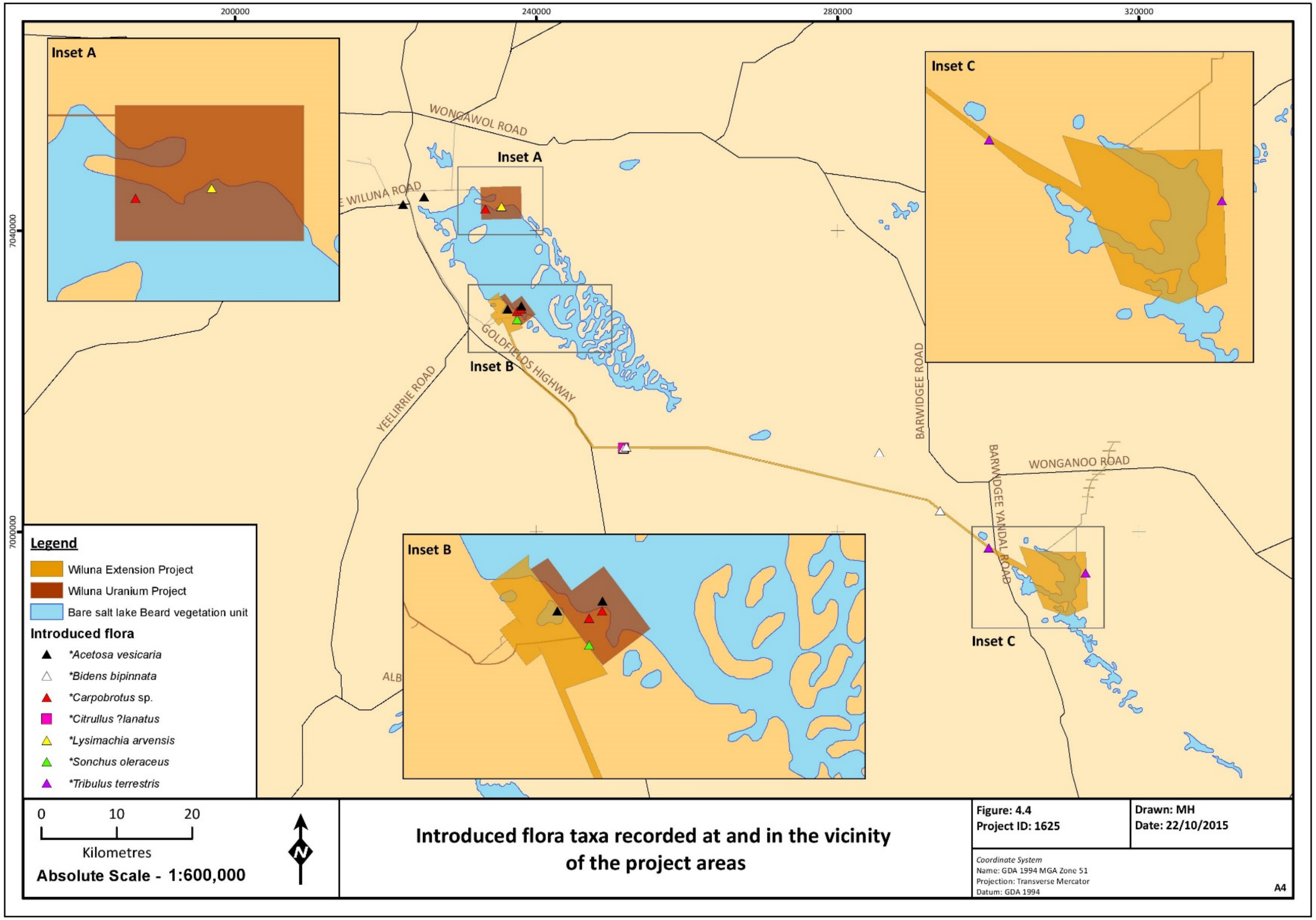
Introduced Flora Overview

The introduced flora taxa identified from the flora and vegetation assessments included in this consolidation are listed in Table 9.15 and locations shown in Figure 9.17. Coordinates are provided electronically in Appendix A of Ecologia 2015g (Appendix 10.49 of the PER).

Table 9.15: Introduced flora taxa of the Wiluna Uranium Project and its Extension

Taxon	Reference	Comment
*_Acetosa vesicaria_	Niche (2011a - Appendix 10.12)	Recorded at the Centipede and Millipede deposits and the West Creek borefields. Four locations totalling approximately 90 individuals.
*_Bidens bipinnata_	Ecologia (2015a - Appendix 10.36)	Recorded along the haul road in large numbers along drainage lines. Four records representing an estimated 1,301 individuals.
*_Brassica tournefortii_^	Niche (2011a - Appendix 10.12)	No information available.
*_Carpobrotus_ sp.	Outback Ecology (2007a – Appendix 10.58)	Recorded from three locations, two at Centipede deposit and one at Lake Way deposit.
*_Centaurea melitensis_^	Niche (2011a - Appendix 10.12)	Recorded from one location in the West Creek Borefield. No specific location data is available.
*_Citrullus ?lanatus_	(Ecologia (2015a - Appendix 10.36)	Scattered at one location in a drainage line along the haul road.
*_Lysimachia arvensis_ (as *_Anagallis arvensis_)	Outback Ecology (2007a – Appendix 10.58)	Recorded from one location at the Lake Way deposit.
*_Sonchus oleraceus_	Niche (2011a - Appendix 10.12)	Recorded from one location at the Centipede deposit.
*_Tribulus terrestris_	Outback Ecology (2009b – Appendix 10.17)	Recorded along the eastern edge of the lake Maitland deposit and along the haul road to the west of Lake Maitland.
	Ecologia (2015a – Appendix 10.36)	

Figure 9.17: Introduced flora taxa at the Wiluna Uranium Project and its Extension



Millipede

During the surveys discussed in Section 9.3, two priority species were recorded:

- *Eremophila arachnoides* Chinnock subsp. *arachnoides* (Scrophulariaceae) (P3); and
- *Stackhousia clementii* Domin (Celastraceae) (P3).

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

Targeted searches for *Eremophila arachnoides Chinnock* subsp. *arachnoides* were completed as a component of the assessment of ecological values associated with the already approved mining at Centipede (EPA Assessment 1819 and EPBC 2009/5174). The targeted searches occurred to the west of the area to be mined at Centipede, incorporating the area that now includes proposed mining at Millipede (Figure 9.18). A total of 8780 linear metres of transects was traversed, covering an area of 43.9 ha. The mean density of records over this area was 22.67 (±16.4) plants per hectare (Niche Environmental Services, 2014 – Appendix 10.13). The high variance was the product of two transects yielding very high densities of 55.2 plants per hectare and 40 plants per hectare. The habitat for this species was identified as *Acacia* woodland on calcrete, with the density dropping rapidly as the calcrete became overlain with shallow clays. The estimate of plants within the habitat in and adjacent to the area to be mined at Millipede was 5440 (±3936). Additional information in relation to the regional distribution of this species is provided in Niche Environmental Services (2011a – Appendix 10.12).

***Stackhousia clementii* Domin**

There were nine records of the Priority Three species *Stackhousia clementii* Domin made during targeted searches, all located within Abercromby Creek (Figure 9.19). There were estimated to be more than 300 individual plants recorded at nine sites. During previous surveys, approximately 500–1000 plants were recorded in a seasonal creek line to the west of Millipede (Niche Environmental Services, 2011a – Appendix 10.12). The plants recorded in Abercromby Creek are located over the Millipede ore body and, as such, these plants are likely to be impacted by the Proposal. However, there are no plans to undertake any ground disturbance in the seasonal creek line in which the 500–1000 plants were previously recorded. As a result, this Proposal would not result in the loss of this species from the area.

Figure 9.18: Priority flora transects for *Eremohila arachnoides Chinnock* subsp. *arachnoides*

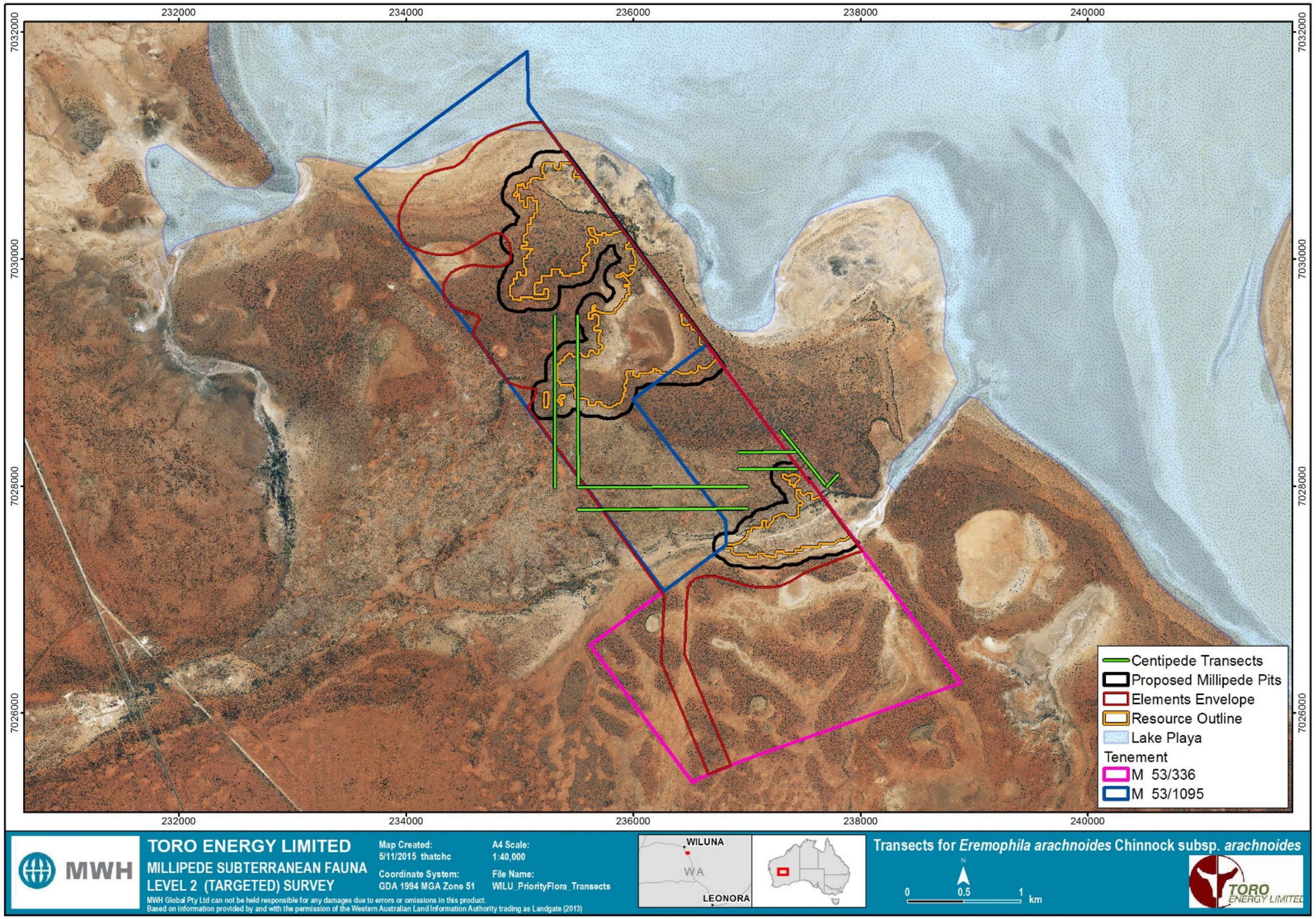
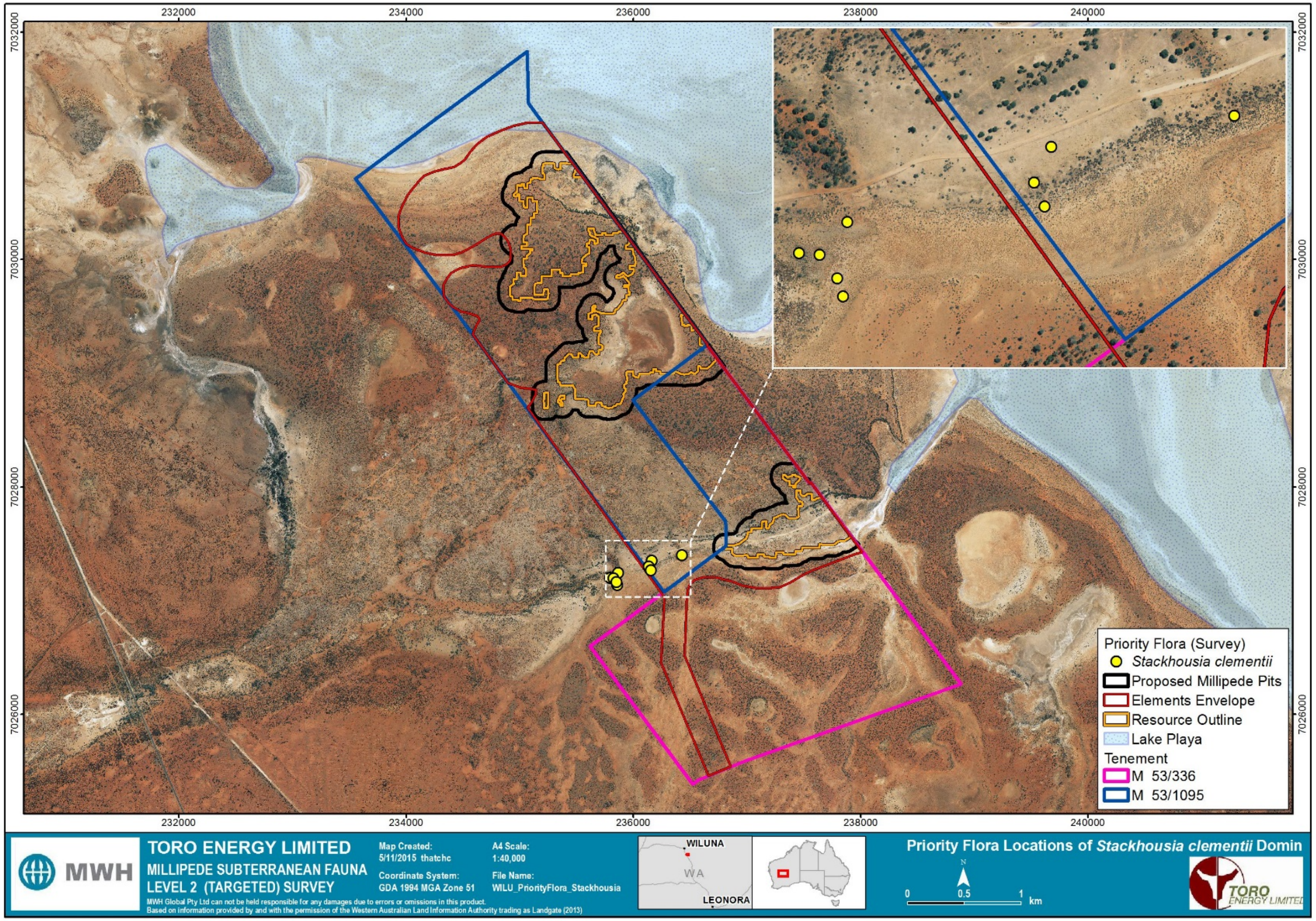


Figure 9.19: Locations of *Stackhousia clementii* Domin



Alien Taxa

There are scattered records of alien taxa, although none of these were species that would be considered to pose significant environmental threats. During initial surveys, there were records of the invasive weed species *Acetosa vesicaria* made at Centipede and a claypan at Millipede (Niche Environmental Services, 2011a – Appendix 10.12). Toro has undertaken an intensive and successful program to control this species.

Bush Tucker Survey

Toro commissioned a survey with Traditional Owners to identify plant species having value for bush tucker or medicinal purposes.

The objective of the survey was to develop a catalogue of bush tucker plants used by Traditional Owners residing in the Wiluna area with a view to providing an insight into potential impacts associated with proposed mining.

The survey involved six Traditional Owners (four men and two women). It comprised vehicle traverses of established tracks within and in the vicinity of proposed mining. When bush tucker plants were identified, a specimen was collected to facilitate identification of the plant with notes taken to document for each plant:

- The use/s;
- Part/s collected;
- Methods of preparation;
- Habitat in which the species were located; and
- Any other information considered relevant.

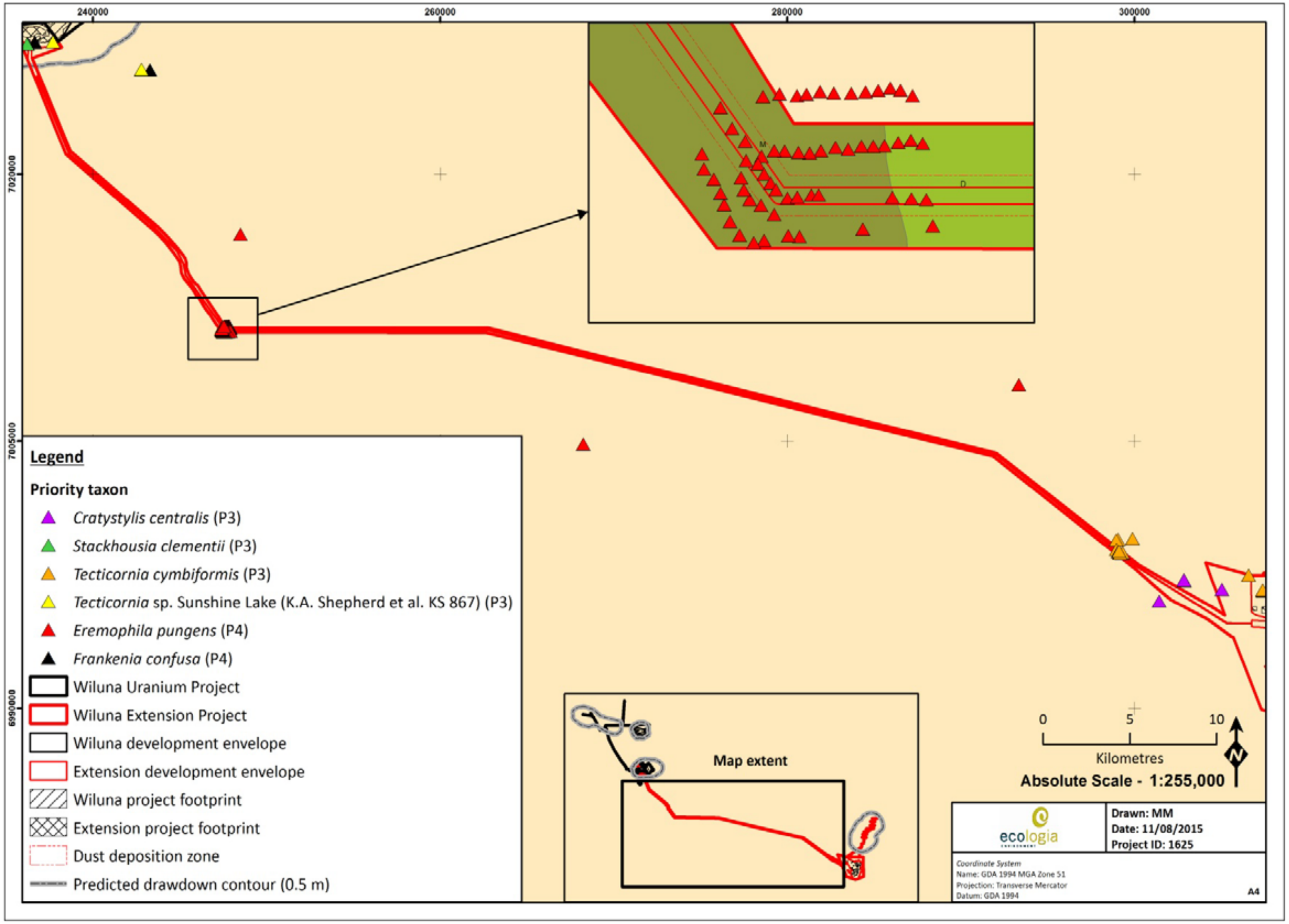
At the completion of the survey, a debrief was conducted with the Traditional Owners to better understand usage patterns and any concerns in relation to impacts associated with proposed mining.

A total of six plants were identified by the Traditional Owners as being used for either food or medicinal purposes. No use was recorded for a seventh plant and an eighth was used exclusively for artefact production. The majority were identified as being bardi plants, which are not in the strictest sense food plants, but serve as host plants for witchetty grubs. Dual uses were noted for a number of bardi plants (Niche Environmental Services, 2011b).

Haul Road

No EPBC Act listed or WC Act listed Threatened Flora taxa were recorded. Two Priority Flora taxa – *Tecticornia cymbiformis* (Priority 3) and *Eremophila pungens* (Priority 4), were recorded within the planned road alignment. Both of these species also occur outside the alignment. Four additional Priority Flora taxa – *Cratystylis centralis* (Priority 3), *Frankenia confusa* (Priority 4), *Stackhousia clementi* (Priority 3) and *Tecticornia* sp. Sunshine Lake (KA Shepherd et al. KS 867) (Priority 1) were recorded outside the area studied in the regional quadrats or opportunistically (Figure 9.20).

Figure 9.20: Significant flora recorded along the haul road



Lake Maitland

The Level 2 Lake Maitland baseline surveys (Outback Ecology, 2009b– Appendix 10.17) included a desktop assessment which revealed a total of 25 species of conservation significance (11 Priority One, one Priority Two, nine Priority Three and four Priority Four species) as potentially occurring in the area studied.

The desktop assessment of the proposed locations of the borefield, accommodation camp and mine access road (Outback Ecology, 2011a – Appendix 10.14) revealed nine Priority species as potentially occurring in the area studied (one Priority One, five Priority Three and three Priority Four), of which five were new additions to the previous searches.

Based on the desktop information gathered from the field surveys, no Threatened Flora species have been positively identified as occurring at Lake Maitland. In November 2007, one specimen collected was initially identified as the DRF species *Eremophila rostrata*. The subsequent flora survey in 2009 enabled this species to be identified as *Eremophila latrobei* subsp. *latrobei*, a non-conservation significant species.

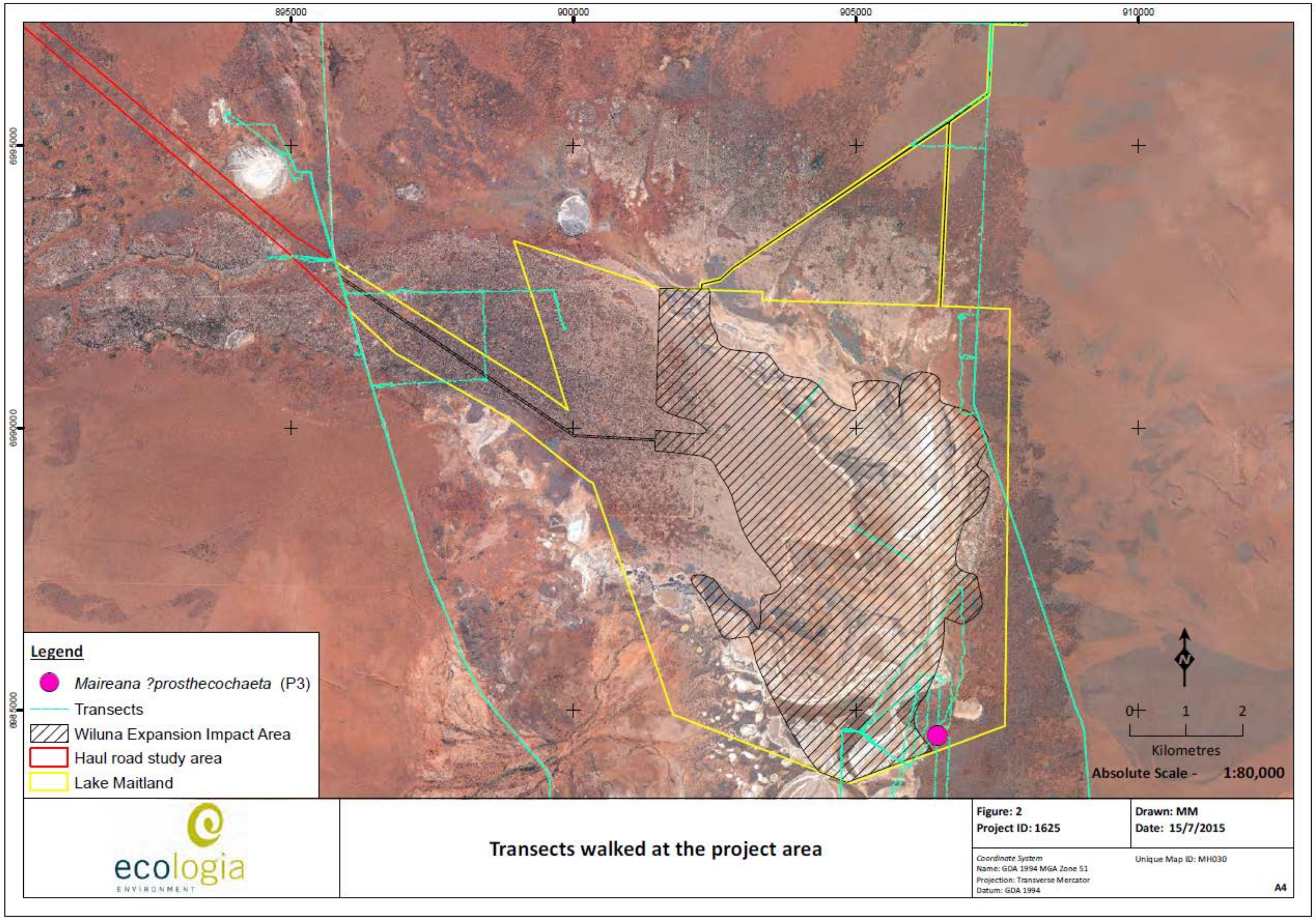
During the Level 1 survey of the borefield, accommodation camp and mine access road, another Priority Three flora species, *Cratystylis centralis*, was recorded. This species was located in sections of the proposed access road and in this location was recorded to be very common with a conservative estimate of over 10,000 individuals reported within calcrete soils. The alignment of the access road would avoid the highest densities of *Cratystylis centralis* population and the impact on the species has been assessed as minimal.

During the Level 2 surveys, one potential Priority Three flora species, *Maireana prosthecochaeta*, was recorded at one location. A single specimen was collected without flowering material and could not be positively identified. To reduce uncertainty about the presence of this species, Toro commissioned a further targeted survey. Approximately 30 km of transects were walked in areas identified from aerial imagery as being the same or similar to the original location where the unconfirmed specimen was collected (Figure 9.21).

Maireana prosthecochaeta was not located during the targeted survey. The original location was visited and no specimen that resembled it was noted. At the original location, there was a very common Chenopodiaceae lower shrub stratum at a density of approximately 10% that was fruiting at the time of the study; this was, however, identified as *Enchylaena tomentosa*.

Based on the outcome of the targeted survey and habitat requirements and proximity of known locations to the Project area, it is considered unlikely for *Maireana prosthecochaeta* to occur at Lake Maitland.

Figure 9.21: *Maireana prosthecochaeta* location



Alien Taxa

A total of 27 weed species have been recorded in the wider region (Pringle *et al.*, 1994), of which five are declared plants under the *Agriculture and Related Resources Protection Act 1976*. These are: *Argemone ochroleuca* (Mexican poppy), *Carthamus lanatus* (Saffron thistle), *Datura stramonium* (Thornapple), *Emex australis* (Double gee) and *Xanthium spinosum* (Bathurst burr).

The 2009 survey identified two weed species, *Portulaca oleracea* and *Tribulus terrestris.* Neither of these species is listed as a declared plant under the *Agriculture and Related Resources Protection Act 1976*.

Bush Tucker Survey

A group consultation was undertaken with representatives of the Barwidgee People to gather information about the type of bush tucker traditionally used in the area. The Barwidgee People communicated traditional plant names and a description of the traditional use and appearance of each plant.

Golder Associates (Golder) was commissioned to determine the scientific (botanical) species name of the traditional names supplied by the Barwidgee People. Golder was able to determine 11 preliminary scientific species names from the traditional names (Golder Associates, 2011h). A field survey was then undertaken with the Barwidgee People to confirm the species names.

Four representatives of the Barwidgee People participated in the field survey and permission was obtained from them to take photographs and collect plant specimens.

The Barwidgee People guided Golder to plants identified for traditional use and the following information was recorded:

- Scientific name (if known); and
- Traditional use of plant as described by Barwidgee People.

The scientific names of some samples were confirmed at the Western Australian Herbarium.

The survey found a total of 27 native vascular flora species used for traditional purposes. Of these, 23 were collected and locations recorded for analysis. The types of bush tucker and traditional uses of the 27 species include:

- Food consumed by humans;
- Medicinal uses;
- Weapons and tools; and
- Plants used for other purposes.

Some species are known to be used for multiple purposes, such as food and tools.

The 27 species were categorised according to the above, as shown in Table 9.16.

Table 9.16: Plant species listed within traditional purpose category

Bush Tucker Category	Species
Food consumed by humans	*Acacia aneura*
	Acacia burkittii
	Acacia pachyacra
	Acacia pruinocarpa
	Acacia ramulosa var. *linophylla*
	Acacia tetragonophylla
	Atriplex nana
	Brachychiton gregorii
	Calandrinia pleiopetala
	Cyperus bulbosus
	Dysphania kalpari
	Enchylaena lanata
	Enchylaena tomentosa var. *tomentosa*
	Eragrostis eriopoda
	Lysiana casuarinae
	Marsdenia australis
	Psydrax rigidula
	Rhyncharrhena linearis
	Santalum acuminatum
	Santalum spicatum
	Solanum coactiliferum
	Triodia basedowii
Medicinal uses	*Lawrencia helmsii*
	Lycium austral
Weapons or tools	*Acacia tetragonophylla*
	Casuarina pauper
	Triodia basedowii
Plants used for other purposes	*Codonocarpus cotinifolius*
	Eremophila longifolia

9.4.4 *Tecticornia*

This section provides discussion about the occurrence of individual *Tecticornia* taxa and of vegetation assemblages within which *Tecticornia* are considered as important species in the area in which this Proposal would be implemented.

Background

Samphires are a group of salt tolerant land plants which often comprise the dominant vegetation in habitats along coastlines, estuaries and inland salt lakes. Two genera are currently recognised in Australia: *Sarcocornia* and *Tecticornia.* The latter genus includes the four former genera *Halosarcia, Pachycornia, Sclerostegia* and *Tegicornia* (Shepherd *et al*. 2004; Shepherd & Wilson 2007). The genus *Tecticornia* is biologically complex and different taxa can be genetically very similar (Shepherd *et al.*, 2004). There is some evidence that *Tecticornia* species may hybridise when they occur in close spatial proximity to each other.

The genus *Tecticornia* is considered to be one of the most taxonomically challenging groups in Australia. Plants belonging to this genus typically have reduced morphology, with tiny flowers and no true leaves but instead succulent 'articles'. The plants exhibit morphological plasticity, so that young seedlings or new seasonal growth can appear quite different in size and colour to adult plants or older branches. As a result, specimens collected from different parts of the same plant, and plants from the same species growing in different parts of the same playa, can appear quite different. In some cases fruits and seeds of a given *Tecticornia* species are distinctive and can be used to identify a sample, but the seeds are very small and generally need to be examined microscopically. These characteristics make both field identification and taxonomy of the genus *Tecticornia* particularly difficult and partly explain why the taxonomy of this group remains unresolved.

Even though samphires are dominant in the vegetation of saline landscapes, detailed information about their basic biology and ecology is lacking (but see Barrett, 2006, Datsun, 2005 and Coleman & Cook, 2009). Considerable research into *Tecticornia* and similar halophytic vegetation over the past – two to three decades has focussed on plant salinity tolerance (Purvis *et al.,* 2009; English & Colmer, 2013). More recent work has explored the effects of inundation on plant health, germination and survival (Colmer *et al.,* 2009; English & Colmer, 2011; Van Etten *et al.,* 2009). Relatively little work has been done on the response of *Tecticornia* to natural drought or anthropogenic reduction in water availability (FMG, 2014, Marchesini *et al.,* 2014).

Halophytes such as *Tecticornia* often have special adaptations that allow them to respond to high salinity and lack of water (UWA, 2012). Physiologically, the effects of high salinity can be very similar to the effect of dryness. It is therefore not surprising that some of the mechanisms that protect *Tecticornia* against high salinity also make the plants tolerant of low water availability. One of the few studies to specifically examine differences between the responses of *Tecticornia* to drought (Marchesini *et al.,* 2014) found that although *Tecticornia* species from different parts of the landscape (upper dune, lower dune, playa) may show quite pronounced physiological differences under normal environmental conditions, 'physiological responses to drought were similar, despite significant differences in transpiration rates, osmotic potentials and tissue water contents in well-watered conditions.' The research by Marchesini *et al.* found that the three *Tecticornia* species studied showed similar responses to drying soil and had similar soil moisture thresholds at which the plants were not able anymore to take up water. That is, there was no evidence that different species of *Tecticornia* responded differently to low water availability, although it is known that species may show differing sensitivity to inundation (English & Colmer, 2011).

What the available research on *Tecticornia* ecology seems to suggest is that the distribution of various *Tecticornia* species is not dictated by how they respond to salinity or dry conditions: necessarily, *Tecticornia* growing in arid, saline environments are all fairly drought-tolerant and salt-tolerant (van Etten & Vellekoop, 2009, Marchesini *et al.,* 2014). It is the responses to flooding and fresh water that seem to differentiate the species. Species that live on the playa (as opposed to on the dunes surrounding the playa) are better able to tolerate prolonged flooding and may require inundation by fresh water to germinate.

Assessments of Tecticornia for the Wiluna Uranium Project and its Extension

Tecticornia communities were assessed during surveys in 2007, 2009 and 2014. However, this work cannot be used for further analysis due to potentially inconsistent identifications and lack of availabile data. *Tecticornia* identifications from a survey by Niche Environmental Services in 2011 (Niche, 2011a – Appendix 10.12) at Lake Way and Centipede (including resurveying of some of the previous work) and by Ecologia in 2015 were identified by Dr Kelly Shepherd, Senior Research Scientist, Western Australian Herbarium, and have been used in this assessment (Ecologia, 2015e – Appendix 10.7).

Field Assessment

Two phases of surveys were conducted from 24 to 28 November 2014 and 9 to 13 January 2015. As recommended by Actis (2012 - Appendix 10.61) and the OEPA, 3 x 3 m quadrats were surveyed along transects from the terrestrial vegetation adjacent to Lake Way and Lake Maitland, across the fringe profile of the lakes.

Transect length varied depending on the extent of *Tecticornia* dominated vegetation at each site. Quadrat locations along each transect were chosen to represent zonation of evident across the lake profile, with at least two quadrats in each zone and consequently, the number and distance between quadrats varied among transects.

A total of 15 transects and 162 quadrats were surveyed during both phases of the survey, of which 12 transects with 129 quadrats were surveyed in November 2014 and three transects, with 33 quadrats surveyed in January 2015 (Table 9.17).

At Lake Way, 10 transects (80 quadrats) were established, of which 39 quadrats were located within the Millipede project area and 41 quadrats in nearby parts of Lake Way (Figure 9.22). At Lake Maitland, five transects (82 quadrats) were established, with 58 quadrats located within the area where mining would occur and 24 quadrats in nearby parts of Lake Maitland (Figure 9.23). The length and number of quadrats per transect are provided in Table 9.17.

Table 9.17: Location of transects, length and number of quadrats

Transect number	Phase	Length (m)	Number of quadrats	Location
1	November 2014	400	12	Lake Way
2	November 2014	600	14	Lake Way
3	November 2014	250	10	Lake Way
4	November 2014	180	6	Lake Way
5	November 2014	100	4	Lake Way
6	November 2014	60	3	Lake Way
7	November 2014	1,500	20	Lake Maitland
8	November 2014	1,700	15	Lake Maitland
9	November 2014	1,200	14	Lake Maitland
10	November 2014	2,000	16	Lake Maitland
11	November 2014	300	8	Lake Way
12	November 2014	200	7	Lake Way
13	January 2015	370	9	Lake Way
14	January 2015	1,100	17	Lake Maitland
15	January 2015	300	7	Lake Way

Figure 9.22: Transect locations at Lake Way (Millipede/Centipede)

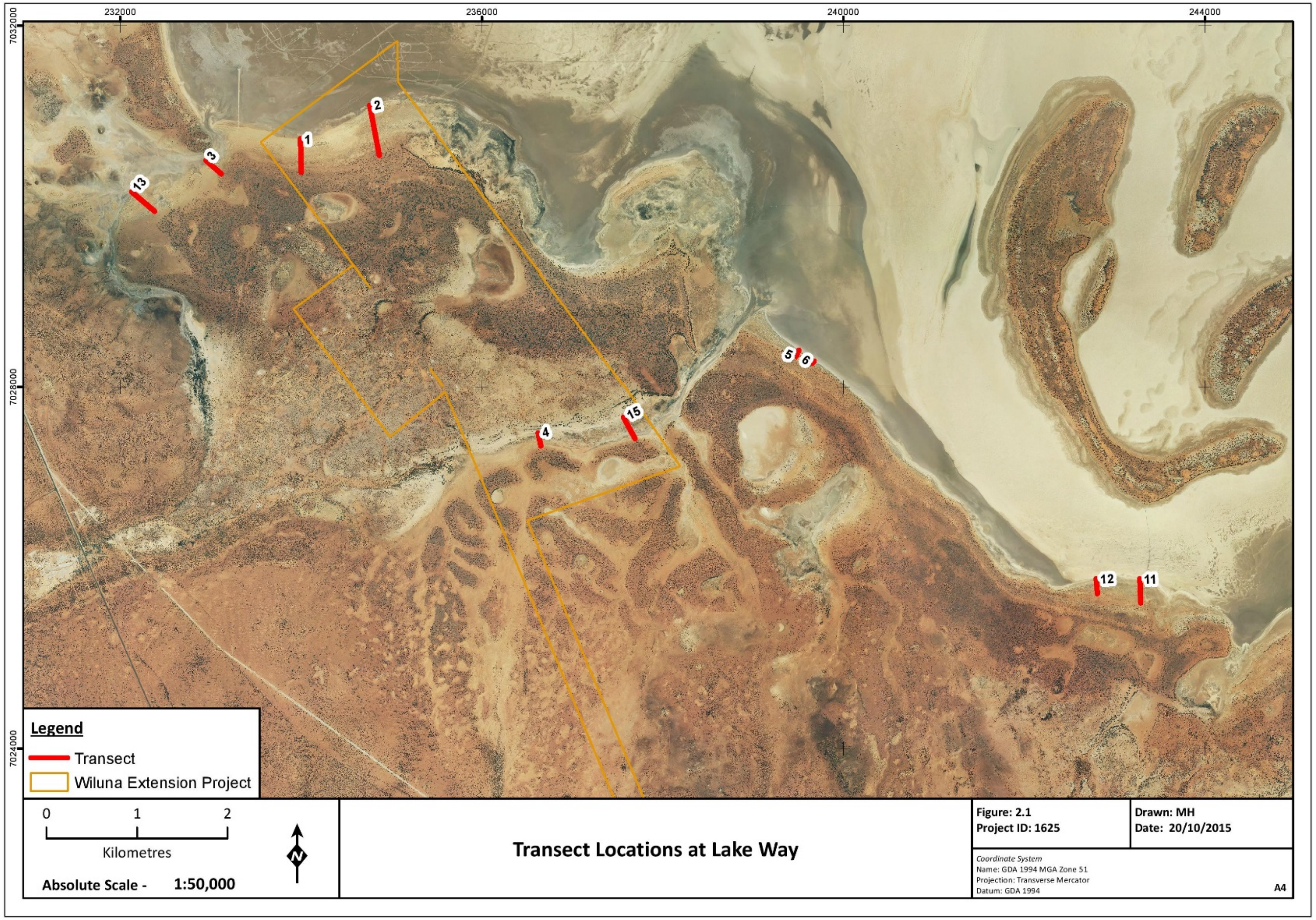
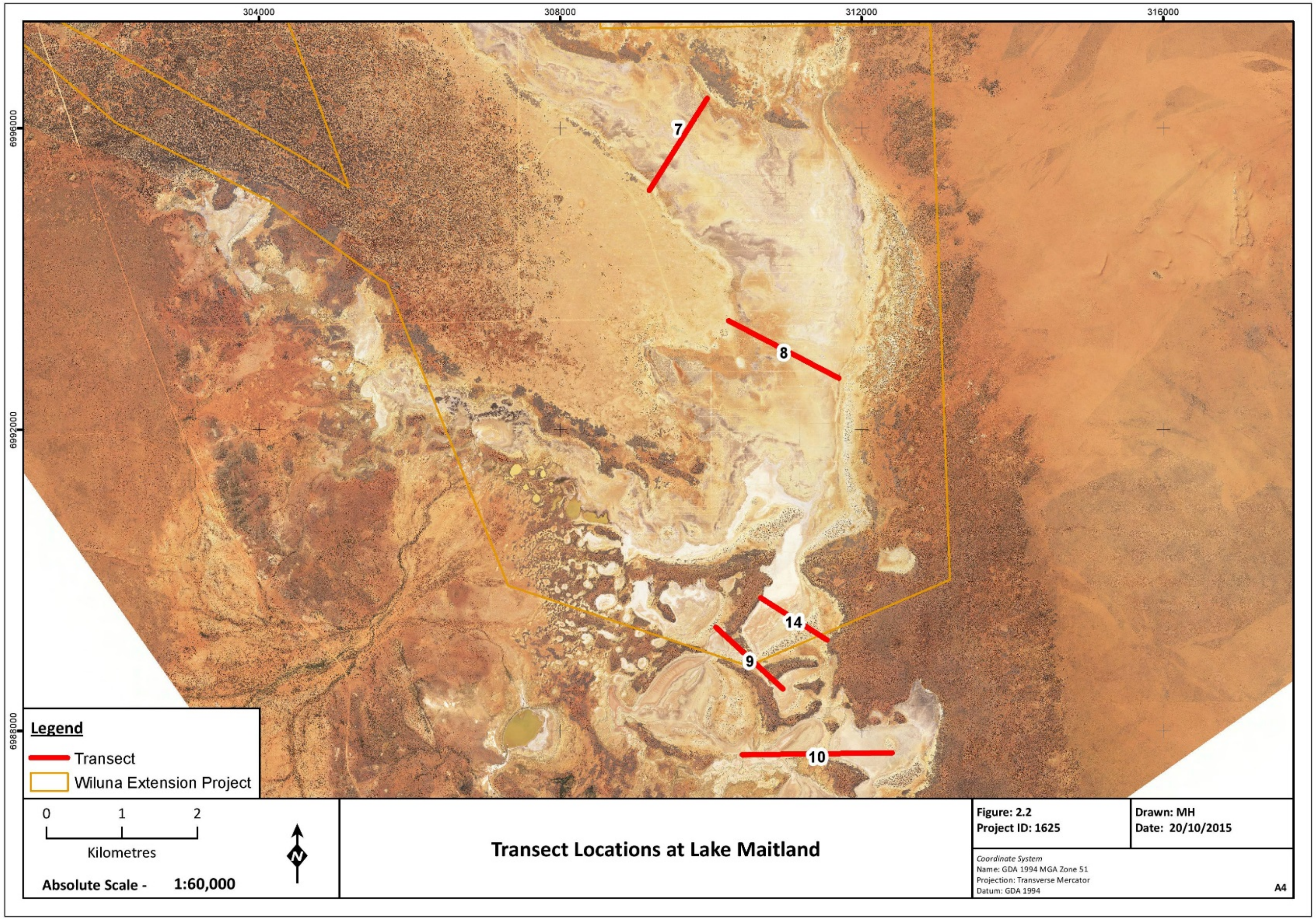


Figure 9.23: Transect locations at Lake Maitland



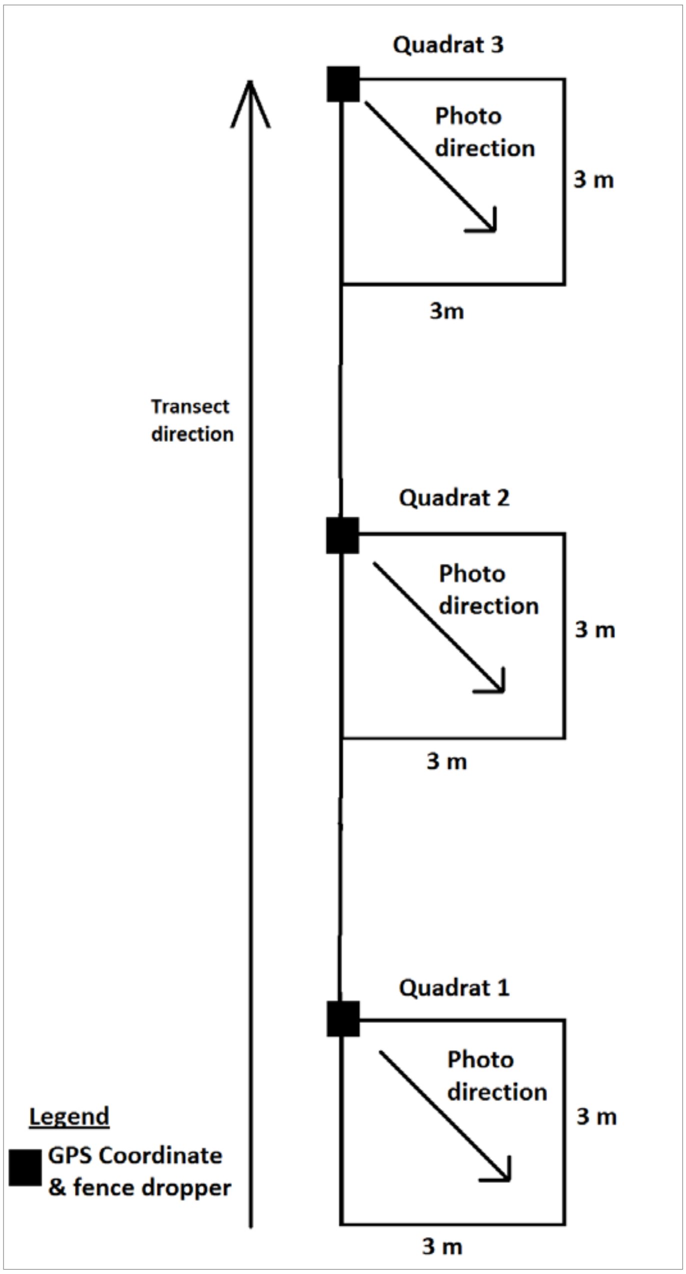
A schematic diagram of a sampling site is shown in Figure 9.24.

The start of the transect line is established in the terrestrial vegetation adjacent to the lake, with the quadrats placed across the profile of the lake fringe. The following was recorded at each quadrat:

- Vegetation structure (National Vegetation Information System, NVIS) (ESCAVI 2003);
- All observed plant species and their average height and cover (using the ranges cited by NVIS);
- Photograph of each *Tecticornia* specimen collected;
- GPS co-ordinate of the top corner, which was permanently marked with a fence dropper or marker flag; and a
- Digital photograph of the quadrat vegetation, taken from the top corner facing 135°.

Locations of quadrats, photographs and a site by species matrix are provided electronically as Appendix A of Ecologia 2015e (Appendix 10.7 of the PER).

Figure 9.24: Schematic of transect



Specimen Identification

Nomenclature follows species concepts currently adopted by the Western Australian Herbarium (WAH), unless otherwise indicated. Specimens that were believed to differ significantly from typical material are indicated with 'affinity' (aff.). Specimens that could not be adequately identified to genus or species level due to the absence of sufficient material were indicated with a question mark.

Tecticornia specimens were identified by Senior Research Scientist at the WAH, Dr. Kelly Shepherd and these identifications (Shepherd 2015 - Appendix 10.33) were used for the analysis of the data presented in this report. This included specimens from the current survey and Ecologia's (2015a - Appendix 10.36) haul road survey.

Shepherd (2015 - Appendix 10.33) conducted a detailed assessment of field tag names and has presented a potential issue with the accuracy of any locations for taxa that were not collected and unvouchered due to identical field names being used for different taxa. However, only specimens along the same transect and within a short distance of each other referred to a vouchered collection and many field names were knowingly given to different taxa. The unvouchered records have therefore been included in this report, but are identified as 'Current survey (not collected)' for clarification.

In total, 134 specimens were matched to field numbers for the 3 x 3 m quadrats sampled during the current assessment and 77 for the Ecologia (2015a – Appendix 10.36) haul road quadrats, totalling 211 vouchered specimens. Inferences made using the field names included an additional 138 records for the current survey and 20 locations for the Ecologia (2015a – Appendix 10.36) haul road survey.

Tecticornia Specimens

For each specimen collected by Ecologia during the current and the haul road surveys, the collection number, coordinates and photographs (if available) are provided electronically in Appendix A of Ecologia 2015e, (Appendix 10.7 of the PER).

For the Niche (2011a - Appendix 10.12) survey of the Centipede and Lake Way deposits, 18 quadrats were completed at the Lake Way deposit, ten were completed at the Centipede deposit and 11 were conducted regionally. It is unknown how many of these specimens were collected as the data is not available. Locations of these taxa are also provided electronically in Appendix A of Ecologia 2015e, (Appendix 10.7 of the PER).

All records of species referred to in this report are therefore identified as:

- Current survey & Ecologia (2015a - Appendix 10.36) (collected);
- Current survey & Ecologia (2015a - Appendix 10.36) (not collected); and
- Niche (2011a - Appendix 10.12)

If there were any inconsistencies between field and identified names on the same transect, the unvouchered records were not included in the results.

Based on the spreadsheet provided by Dr. Shepherd, a number of specimens could not be matched to Ecologia's field number and have not been included in the results.

A total of 27 specimens were sterile and have not been included in the results.

Plant Count Estimates

Where only a cover was available for *Tecticornia* taxa recorded during the surveys, the number of plants has been estimated. The number of plants estimated from cover descriptions is detailed in Table 9.18.

Table 9.18: Number of plants assumed for records with only a percentage cover or a description

Cover or description	No. of plants assumed
No cover or number	1
Infrequent, not common, occasional, rare, scattered, sparse	5
Common, locally common, frequent	50
Abundant	100
<1% cover	1
1–2% cover	5
2–10 % cover	10
10–30 % cover	20
30–70 % cover	50
70–100 % cover	100

As there were no cover or abundance data available for the quadrats completed by Niche (2011a – Appendix 10.12), each location has been given an estimate of one plant and therefore the estimates for these areas are conservative.

Tecticornia Community Cluster Analysis

Statistical analysis provides an objective means of defining vegetation units and provides insight into the hierarchical relationship between communities based on the degree of similarity in species composition and abundance.

Multivariate analysis was conducted using the site by species matrix from the quadrats completed during the two phases of field survey. Any quadrats containing specimens that were not able to be identified were not used for statistical analysis and therefore 150 quadrats were used in the statistical analysis. In order to best align the vegetation analysis, the data from the species by site matrix was treated in that:

- Data was transformed to presence/absence;
- Taxa were removed from the data or in some cases grouped together if they could not be confidently identified to species level and there was a possibility of confusion with other similar taxa;
- Annual taxa were removed; and
- Subspecies and varieties of the same species were combined.

An association matrix of the Bray-Curtis coefficient was calculated from the site by species data in PATN v3.11. This was then used to perform hierarchical cluster analysis using the Unweighted Pair Group Method with Arithmetic mean (UPGMA) in PATN v3.11. The clustering patterns from the resultant dendrogram were used to delineate vegetation units. Vegetation units were then described on the basis of the most prevalent species within the quadrats of the vegetation unit.

Results – *Tecticornia* Taxa

A total of 20 known *Tecticornia* taxa were identified in total at or in the vicinity of the Project area, 18 from Lake Way and 15 from Lake Maitland, including three Priority flora taxa; *Tecticornia* sp. Lake Way (P. Armstrong 05/961) (Priority 1), *Tecticornia* sp. Sunshine Lake (K.A. Shepherd *et al.* KS 867) (Priority 1) and *Tecticornia cymbiformis* (Priority 3) (Table 9.19).

In addition to these known *Tecticornia* taxa, seven novel taxa for the current and haul road survey areas and two possibly novel taxa were identified (Table 9.19). The individuals representing the two potentially novel taxa were sterile, but display unusual characteristics and are also listed in Table 9.19. Niche (2011a – Appendix 10.12) recorded four taxa that were identified as unknown and potentially novel taxa at the study area. It is likely that some of these taxa are the same as the unknown taxa identified for the current survey, but as the specimens were not available, a direct comparison is not possible and they have therefore been treated as separate entities.

Each *Tecticornia* entity is mapped in Appendix B of Ecologia 2015e (Appendix 10.7 of the PER).

Table 9.19: *Tecticornia* entities recorded at or in the vicinity of the study area

Tecticornia entity	Lake Way	Lake Maitland
Known taxa (Shepherd 2015 - Appendix 10.33) & Niche 2011a – Appendix 10.12)		
Tecticornia calyptrate	X	X
Tecticornia cymbiformis **(Priority 3)**	-	X
Tecticornia disarticulate	X	X
Tecticornia doleiformis	X	X
Tecticornia halocnemoides subsp. *catenulata*^ **(range extension)**	X	-
Tecticornia indica subsp. *bidens*	X	X
Tecticornia indica subsp. *leiostachya*	X	X
Tecticornia laevigata	X	X
Tecticornia moniliformis^ **(range extension)**	X	-
Tecticornia peltata	X	X
Tecticornia pergranulata	X	-
Tecticornia pruinosa	X	X
Tecticornia pterygosperma subsp. *denticulate*	X	X
Tecticornia pterygosperma subsp. *pterygosperma* **(range extension)**	-	X
Tecticornia sp. Burnerbinmah (D. Edinger et al. 101)	X	X
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	X	X
Tecticornia sp. Lake Way (P. Armstrong 05/961) **(Priority 1)**	X	-
Tecticornia sp. Sunshine Lake (K.A. Shepherd et al. KS 867) **(Priority 1)**	X	X
Tecticornia tenuis **(range extension)**	X	-
Tecticornia undulata	X	X
Novel taxa (Shepherd 2015 – Appendix 10.33)		
Tecticornia aff. *halocnemoides* s.l. 'large ovate seed aggregate'	X	X
Tecticornia aff. *halocnemoides* s.l. 'tuberculate seed'	-	X
Tecticornia sp. aff. *globulifera* (small)	X	X
Tecticornia sp. aff. *laevigata* (non-rotated fruitlets)	X	X
Tecticornia sp. aff. *pruinosa* (inflated bracts)	-	X
Tecticornia sp. aff. Burnerbinmah (inflated fruit)	X	-
Tecticornia sp. aff. *undulata* (broad articles)	X	X

Tecticornia entity	Lake Way	Lake Maitland
Potentially novel taxa (Shepherd 2015 – Appendix 10.33)		
Tecticornia aff. *halocnemoides* (unusual epidermis)	-	X
?Tecticornia sp. aff. *globulifera* (small)	X	X
Potentially novel taxa (Niche 2011a – Appendix 10.12)		
Tecticornia sp. *halocnemoides* beaked seed aggregate^	X	-
Tecticornia sp. aff. *laevigata*^	X	-
Tecticornia sp. aff. *pruinosa*^	X	-
Tecticornia sp. aff. *undulata*^	X	-

^ = Identified by Niche (2011).

Significance of Tecticornia Taxa

The location, number and potential for occurrence inside and outside the impact areas for each of the 33 *Tecticornia* entities are listed in Table 9.20 and discussed below.

Priority *Tecticornia* Taxa

The Priority 1 taxon, *Tecticornia* sp. Lake Way (P. Armstrong 05/961) was recorded from one location in Lake Way and is apparently restricted to a small outwash plain approximately 5 km south of the Millipede and Centipede deposits. Due to the extensive targeted searches and a likely restricted habitat it is given a low likelihood of suitable habitat within the Project area.

The Priority 1 taxon, *Tecticornia* sp. Sunshine Lake (K.A. Shepherd *et al.* KS 867) was recorded frequently at both Lake Maitland and Lake Way. At Lake Maitland it was recorded in the smaller salt pans towards the southern end of the lake, and at Lake Way it was recorded along the very edge of the bare salt lake. Because of this it is considered to have a high likelihood of additional habitat outside the Project area.

Tecticornia cymbiformis (Priority 3) appears to be isolated to the one small salt pan to the west of Lake Maitland and the upper edge of the main bed of Lake Maitland itself. Because of this, it has been given a low likelihood of additional habitat outside of the Project area.

Novel *Tecticornia* Taxa

Of the 13 novel or potentially novel *Tecticornia* taxa, *Tecticornia* sp. aff. Burnerbinmah (inflated fruit) was found at one location at the southern end of the proposed Millipede mining pit and *Tecticornia* sp. aff. *pruinosa* (inflated bracts) was also found at one location to the north of the proposed Lake Maitland development envelope.

Known *Tecticornia* Taxa

Most of the known taxa are widespread in Western Australia and have a high likelihood of occurrence outside the Project area (Table 9.20). Four taxa are considered range extensions and are discussed individually below.

Tecticornia halocnemoides subsp. *catenulata* is known from approximately 200 km west of the Project area and represents a slight range extension from the vouchered specimens at the WAH. It was recorded at 11 locations at the Centipede and Lake Way deposits and is considered to have a high likelihood of occurrence outside the Project area.

Tecticornia moniliformis is known from approximately 400 km south of the Project area and represents a large range extension from the vouchered specimens at the WAH. It was recorded commonly at the Centipede and Lake Way deposits on the main lake bed and minor tributaries and is therefore considered to have a high likelihood of occurrence outside the Project area.

Tecticornia pterygosperma subsp. *pterygosperma* is known from approximately 200 km south of the Project area. It was recorded at one location at Lake Maitland, on a small salt pan to the south of the main lake bed. As this habitat occurs extensively outside the Project area, it is considered that this taxon has a high likelihood of occurrence outside the areas studied.

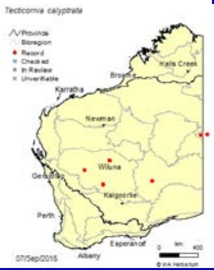
Tecticornia tenuis is known from approximately 500 km south-west and 1,000 km north-east of the Project area. It represents a significant bridging record from the vouchered specimens at the Western Australian Herbarium (WAH). It was recorded at three locations from Lake Way on the floodplain to the south of Millipede which occurs well beyond the survey area and therefore has a high likelihood of occurrence outside the Project area.

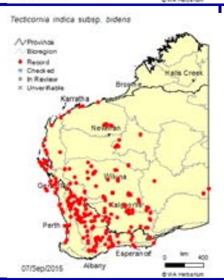
Table 9.20: Number, location and habitat of *Tecticornia* taxa

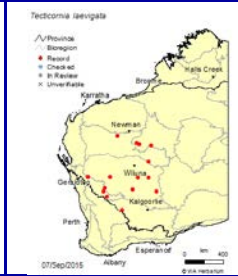
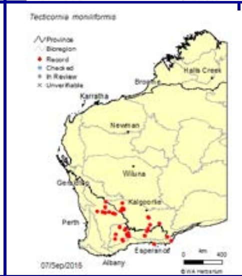
Taxa	Status	Florabase WA Distribution	Number of plants (locations) at Lake Maitland	Number of plants (locations) at Lake Way	Number of quadrats recorded regionally	Habitat recorded on at the study area	Likelihood of additional habitat
Tecticornia sp. Lake Way (P. Armstrong 05/961)	Priority 1		0	2,000 (4)	0	Lake Way: Restricted to a small outwash plain connected to the main salt lake.	Low likelihood of additional habitat. The small outwash plain it occurs on is not widespread in the area. Also extensive targeted searches at Lake Way have yielded no additional records.
Tecticornia sp. Sunshine Lake (K.A. Shepherd *et al.* KS 867)	Priority 1		86 (10)	116 (14)	0	Lake Way: Was recorded on the edge of the main salt lake and minor tributaries. Appears to be mostly restricted to the very edge of *Tecticornia* communities bordering on the bare lake bed. Lake Maitland: Common on the small salt pan trail that runs south from the main lake bed.	High likelihood of additional habitat. The trail of small salt pans extends well beyond the survey area at Lake Maitland and was recorded on multiple locations on the edge of the salt lake at Lake Way.
Tecticornia cymbiformis	Priority 3		5,480 (25)	0	0	Lake Maitland: Scattered along the upper edge of the main lake bed and forming part of the vegetation community of a small salt pan to the west of Lake Maitland.	Low likelihood of additional habitat. Seems to be isolated to the one small salt pan to the west of Lake Maitland and the upper edge of the main lake bed.

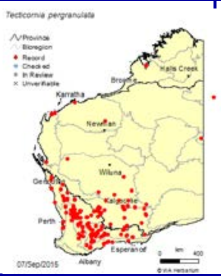
Taxa	Status	Florabase WA Distribution	Number of plants (locations) at Lake Maitland	Number of plants (locations) at Lake Way	Number of quadrats recorded regionally	Habitat recorded on at the study area	Likelihood of additional habitat
Tecticornia aff. *halocnemoides* s.l. 'large ovate seed aggregate'	Novel	n/a	67 (8)	51 (5)	0	Lake Way: Common on the edge of the main salt lake and minor tributary to the south of millipede/centipede. Lake Maitland: Common on the main lake bed and trail of small salt pans that run to the south.	High likelihood of additional habitat. Not specific to any uncommon landscape feature.
Tecticornia aff. *halocnemoides* s.l. 'tuberculate seed'	Novel	n/a	55 (6)	0	0	Lake Maitland: Common on the main lake bed and trail of small salt pans that run to the south.	High likelihood of additional habitat. Not specific to any uncommon landscape feature.
Tecticornia sp. aff *globulifera* (small)	Novel	n/a	342 (30)	126 (10)	0	Lake Way: Very common on the edge of the main lake bed and minor tributaries. Lake Maitland: Very common on the main lake bed and on the trail of small salt pans to the south.	High likelihood of additional habitat. Not specific to any uncommon landscape feature.
Tecticornia sp. aff *laevigata* (non-rotated fruitlets)	Novel	n/a	53 (8)	55 (5)	0	Lake Way: Common on the main lake bed and minor tributaries. Lake Maitland: Common on the main lake bed and the small salt pan trail that runs south.	High likelihood of additional habitat. Not specific to any uncommon landscape feature.
Tecticornia sp. aff *pruinosa* (inflated bracts)	Novel	n/a	5 (1)	0	0	Lake Maitland: Scattered in the main lake bed.	Low likelihood of additional habitat. Only recorded on the main lake bed.
Tecticornia sp. aff. Burnerbinmah (inflated fruit)	Novel	n/a	0	1 (1)	0	Lake Way: Recorded scattered on the minor tributary in the south of millipede.	Low likelihood of additional habitat. The minor tributary it occurs on is not extensive in the area.

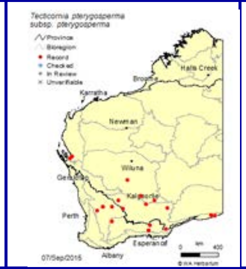
Taxa	Status	Florabase WA Distribution	Number of plants (locations) at Lake Maitland	Number of plants (locations) at Lake Way	Number of quadrats recorded regionally	Habitat recorded on at the study area	Likelihood of additional habitat
Tecticornia sp. aff. *undulata* (broad articles)	Novel	n/a	360 (39)	107 (12)	0	Lake Way: Common on the main lake bed and minor tributaries. Lake Maitland: Very common on the main lake bed and on the trail of small salt pans to the south.	High likelihood of additional habitat. Not specific to any uncommon landscape feature.
Tecticornia aff. *halocnemoides* (unusual epidermis)	Potentially novel	n/a	3 (30)	0	0	Lake Maitland: Scattered at one location in the trail of small salt pans that run to the south.	High likelihood of additional habitat. The trail of small salt pans extends well beyond the survey area at Lake Maitland.
?*Tecticornia* sp. aff *globulifera* (small)	Potentially novel	n/a	1 (20)	1 (5)	0	Lake Way: Scattered on the main lake bed. Lake Maitland: Scattered on the trail of small salt pans that run to the south.	High likelihood of additional habitat. Not specific to any uncommon landscape feature and recorded regionally.
Tecticornia sp. aff *laevigata*	Potentially novel	n/a	0	5 (5)	4	Lake Way: Common on the main lake bed of the centipede and millipede deposits and on the main tributary that runs north from the Lake Way deposit.	High likelihood of additional habitat. Not specific to any uncommon landscape feature and recorded regionally.
Tecticornia sp. aff *pruinosa*	Potentially novel	n/a	0	27 (27)	0	Lake Way: Very common on the main lake bed of the centipede/Millipede deposits and Lake Way deposits. Also recorded on the minor tributaries of both areas.	High likelihood of additional habitat. Not specific to any uncommon landscape feature.
Tecticornia sp. aff *undulata*	Potentially novel	n/a	0	16 (16)	8	Lake Way: Very common on the main lake bed of the centipede/Millipede deposits and Lake Way deposits. Also recorded on the minor tributaries of the Lake Way deposit.	High likelihood of additional habitat. Not specific to any uncommon landscape feature.

Taxa	Status	Florabase WA Distribution	Number of plants (locations) at Lake Maitland	Number of plants (locations) at Lake Way	Number of quadrats recorded regionally	Habitat recorded on at the study area	Likelihood of additional habitat
Tecticornia sp. *halocnemoides* 'beaked seed aggregate'	Potentially novel	n/a	0	15 (15)	1	Lake Way: Common on the main lake bed and the minor tributary running north from the Lake Way deposit.	High likelihood of additional habitat. Not specific to any uncommon landscape feature and recorded regionally.
Tecticornia calyptrata	-		1 (10)	6 (19)	2	Lake Way: Common on the minor tributary and floodplains to the south of Millipede and a small salt pan at the lake Way deposit. Lake Maitland: One location on the small salt pan trail that runs south from the main lake bed.	High likelihood of additional habitat. Not specific to any uncommon landscape feature.
Tecticornia disarticulata	-		3 (3)	20 (3)	2	Lake Way: On a floodplain to the west of the main lake. Lake Maitland: On a small floodplain to the west of the main lake bed with scattered *Tecticornia*.	High likelihood of additional habitat. The floodplain it occurs on extends well beyond the survey areas at both Lake Way and Lake Maitland.
Tecticornia doleiformis	-		2 (2)	3 (3)	0	Lake Way: On a minor tributary in the south of the millipede/centipede deposit and on the main lake bed of the Lake Way deposit. Lake Maitland: Scattered on a small salt pan to the west of Lake Maitland.	High likelihood of additional habitat. On the small salt pans and tributaries that are not large features in the area

Taxa	Status	Florabase WA Distribution	Number of plants (locations) at Lake Maitland	Number of plants (locations) at Lake Way	Number of quadrats recorded regionally	Habitat recorded on at the study area	Likelihood of additional habitat
Tecticornia halocnemoides subsp. *catenulata*	-		0	11 (11)	0	Lake Way: Very common across the main lake bed of the centipede deposit and scattered on the main lake bed of the Lake Way deposit	High likelihood of additional habitat. Not specific to any uncommon landscape feature.
Tecticornia indica subsp. *bidens*	-		99 (13)	103 (35)	7	Lake Way: Very common on the fringe of the main salt lake at centipede/millipede and Lake Way deposits, as well as the minor tributaries and floodplains. Lake Maitland: Common in the main lake bed and small salt pans of the south and west of Lake Maitland.	High likelihood of additional habitat. Not specific to any uncommon landscape feature.
Tecticornia indica subsp. *leiostachya*	-		40 (4)	79 (10)	0	Lake Way: Common on the fringe of the main salt lake, minor tributaries and floodplains and scattered in a minor tributary at the Lake Way deposit. Lake Maitland: Common on the small salt pan to the west of Lake Maitland.	High likelihood of additional habitat. Not specific to any uncommon landscape feature.

Taxa	Status	Florabase WA Distribution	Number of plants (locations) at Lake Maitland	Number of plants (locations) at Lake Way	Number of quadrats recorded regionally	Habitat recorded on at the study area	Likelihood of additional habitat
Tecticornia laevigata	-		2,370 (35)	42 (29)	4	Lake Way: Very common on the fringe of the main salt lake at centipede/millipede and Lake Way deposits, as well as the minor tributaries and floodplains. Lake Maitland: Very common on the main lake bed and small salt pans to the south and west of Lake Maitland.	High likelihood of additional habitat. Not specific to any uncommon landscape feature.
Tecticornia moniliformis	-		0	11 (11)	1	Lake Way: Very common at the centipede deposit main lake bed and minor tributary and scattered on the main lake bed at the Lake Way deposit.	High likelihood of additional habitat. Not specific to any uncommon landscape feature.
Tecticornia peltata	-		258 (20)	65 (20)	2	Lake Way: Common on the fringe of the main salt lake, minor tributaries and floodplains of the centipede and millipede area and Lake Way deposit. Lake Maitland: Very common on the small trail of salt pans to the south of the main lake bed and on the small salt pan to the west.	High likelihood of additional habitat. Not specific to any uncommon landscape feature and recorded regionally.

Taxa	Status	Florabase WA Distribution	Number of plants (locations) at Lake Maitland	Number of plants (locations) at Lake Way	Number of quadrats recorded regionally	Habitat recorded on at the study area	Likelihood of additional habitat
Tecticornia pergranulata	-		0	5 (1)	0	Lake Way: On the floodplains to the south of the Millipede and Centipede deposits.	High likelihood of additional habitat. The floodplain it occurs on extends well beyond the survey area at Lake Way.
Tecticornia pruinosa	-		21 (3)	2 (2)	3	Lake Way: On the floodplains to the south of the Millipede and Centipede deposits and on the minor tributary running north from the Lake Way deposit. Lake Maitland: Recorded on the main lake bed only.	High likelihood of additional habitat. The floodplain it occurs on extends well beyond the survey area at Lake Way but is on the main lake bed at Maitland and has been recorded regionally.
Tecticornia pterygosperma subsp. *denticulata*	-		1 (1)	33 (6)	0	Lake Way: Scattered on the fringe of the main salt lake, minor tributaries and floodplains. Lake Maitland: Scattered on a small salt pan to the west of Lake Maitland.	High likelihood of additional habitat. Not specific to any uncommon landscape feature.

Taxa	Status	Florabase WA Distribution	Number of plants (locations) at Lake Maitland	Number of plants (locations) at Lake Way	Number of quadrats recorded regionally	Habitat recorded on at the study area	Likelihood of additional habitat
Tecticornia pterygosperma subsp. *pterygosperma*	-		10 (1)	0	0	Lake Maitland: occurs on a small salt pan in the trail that runs south from the main lake bed.	High likelihood of additional habitat. The trail of small salt pans extends well beyond the survey area at Lake Maitland.
Tecticornia sp. Burnerbinmah (D. Edinger *et al.* 101)	-		70 (5)	125 (22)	0	Lake Way: Very common on the fringe of the main salt lake at centipede/millipede and Lake Way deposits, as well as the minor tributaries. Lake Maitland: Common on the western edge of the main lake bed.	High likelihood of additional habitat. Not specific to any uncommon landscape feature.
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	-		97 (9)	483 (47)	0	Lake Way: Very common on the fringe of the main salt lake, minor tributaries and floodplains of the centipede/millipede deposits and scattered on the main lake bed of the Lake Way deposit. Lake Maitland: Common on the small trail of salt pans to the south of the main lake bed and on the small salt pan to the west.	High likelihood of additional habitat. Not specific to any uncommon landscape feature.

Taxa	Status	Florabase WA Distribution	Number of plants (locations) at Lake Maitland	Number of plants (locations) at Lake Way	Number of quadrats recorded regionally	Habitat recorded on at the study area	Likelihood of additional habitat
Tecticornia tenuis	-		0	50 (3)	0	Lake Way: Common on the minor tributary and floodplain to the south of Millipede.	High likelihood of additional habitat. The floodplain it occurs on extends well beyond the survey area at Lake Way.
Tecticornia undulata	-		21 (3)	1 (1)	0	Lake Way: Scattered on the main lake bed to the south of the Centipede/Millipede deposit. Lake Maitland: occurs on a small salt pan in the trail that runs south from the main lake bed.	High likelihood of additional habitat. The trail of small salt pans extends well beyond the survey area at Lake Maitland.

Note: Images used with the permission of the Western Australian Herbarium, Department of Parks and Wildlife (https://florabase.dpaw.wa.gov.au/help/copyright). Accessed on Friday, 23 October 2015.

Tecticornia Communities (Current Survey)

Using a statistical analysis of the 3 x 3 m quadrats at the Project area, 15 *Tecticornia*-dominated vegetation units were delineated. Three additional vegetation units (T-A, T-C and T-D) were also delineated, but were not *Tecticornia* dominated and are therefore not described further. Of the 15 *Tecticornia*-dominated vegetation units, 14 were recorded at Lake Way and 11 at Lake Maitland (Table 9.21).

However, in *Tecticornia* vegetation where plants are sparse, a 3 x 3 m quadrat may be too small to provide an adequate sample of the floristic composition, potentially including only one species, and excluding other species that may be common in the surrounding vegetation.

The vegetation units for each quadrat are mapped in Appendix B of Ecologia 2015e (Appendix 10.7 of the PER) showing the location of 33 individual *Tecticornia* taxa. Within transects, similar vegetation units often tended to be grouped together. However, the vegetation units present tended to vary considerably among transects, and many vegetation units were not restricted to any one recognisable zone across the lake profile (e.g. upper, mid or lower zones). Moreover, there was no consistent relationship between the floristic vegetation units delineated and patterns observed in the aerial photography, making mapping of these individual vegetation units impractical.

Table 9.21: Vegetation units deliniated from statistical analysis

Unit code	Vegetation unit	Lake Way	Lake Maitland
		# quadrats	# quadrats
T-A	*Mariana pyramidata* sparse mid shrubland, over *Sclerolaena diacantha* and *Dissocarpus paradoxus* sparse low shrubland	12	-
T-BA	*Tecticornia* sp. aff *globulifera* (small) sparse low shrubland	3	3
T-BB	*Tecticornia* sp. Burnerbinmah (D. Edinger *et al.* 101) and/or *T. indica* subsp. *leiostachya* sparse low shrubland, with *Sclerolaena cuneata* scattered low shrubs	5	-
T-C	*Triodia plurinervata* open hummock grassland	-	1
T-D	*Eucalyptus striaticalyx* open low woodland	-	1
T-E	*Tecticornia* sp. Dennys Crossing (K.A. Shepherd & J. English KS 552) and *Muellerolimon salicorniaceum* sparse low shrubland	8	-
T-F	*Tecticornia* sp. Dennys Crossing (K.A. Shepherd & J. English KS 552) (+/-*T. indica* subsp. *leiostachya* & *T.* sp. aff. *undulata* (broad articles)), over *Eragrostis falcata* isolated tussock grasses	9	4
T-GA	*Tecticornia pterygosperma* subsp. *denticulate* and *T.* sp. aff. *undulata* (broad articles) sparse low shrubland (+/-*Mariana pyramidata*)	2	-
T-GB	*Tecticornia* sp. aff *globulifera* (small), *Lawrencia helmsii* and *Scaevola collaris* (+/-T. sp. Burnerbinmah (D. Edinger *et al.* 101), *T.* sp. aff *laevigata* (non-rotated fruitlets) and *T. indica* subsp. *leiostachya*) sparse low shrubland	4	6
T-HA	*Tecticornia* sp. Dennys Crossing (K.A. Shepherd & J. English KS 552) (+/-T. sp. aff. *undulata* (broad articles, *T.* sp. aff *globulifera* (small) and *T. indica* subsp. *leiostachya)* and *Sclerolaena clelandii*	12	1
T-HB	*Lawrencia helmsii, Sclerolaena clelandii* and *Sclerolaena fimbriolata* (+/-*Tecticornia* sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)) sparse low shrubland, over *Eragrostis falcata* isolated tussock grasses	3	1
T-IA	*Tecticornia* sp. aff *laevigata* (non-rotated fruitlets) (+/-*T. laevigata*) and *Maireana luehmannii* sparse low shrubland, over *Eragrostis falcata* isolated tussock grasses	2	3
T-IB	*Tecticornia* sp. aff. *undulata* (broad articles) and *T.* sp. Sunshine Lake (K.A. Shepherd *et al.* KS 867) (+/- *T. laevigata*) sparse low shrubland	2	-

Unit code	Vegetation unit	Lake Way # quadrats	Lake Maitland # quadrats
T-IC	*Tecticornia* sp. Sunshine Lake (K.A. Shepherd *et al.* KS 867) *T.* sp. aff *laevigata* (non-rotated fruitlets) sparse low shrubland	1	1
T-JA	*Tecticornia laevigata*, *T.* sp. aff *globulifera* (small) and *T.* sp. aff. *undulata* (broad articles) sparse low shrubland (+/- *Lawrencia densiflora*), over *Eragrostis falcata* sparse tussock grassland	-	27
T-JB	*Tecticornia* sp. aff *globulifera* (small) and *T.* sp. aff. *undulata* (broad articles) (+/-*T. peltata* and *T.* aff *halocnemoides* s.l. 'large ovate seed aggregate'), over *Eragrostis falcata* isolated tussock grasses	2	12
T-K	*Tecticornia* sp. Sunshine Lake (K.A. Shepherd *et al.* KS 867) sparse shrubland	3	3
T-L	*Tecticornia peltata* (+/-*T.* sp. aff *globulifera* (small) and *T.* sp. Sunshine Lake (K.A. Shepherd *et al.* KS 867) sparse low shrubland, over *Eragrostis falcata* isolated tussock grasses	5	12

Note: Shading represents non-Tecticornia dominated communities

Due to the possible overestimation of the vegetation units using the floristic analysis of the 3 x 3 m quadrats (due to this quadrat size insufficiently sampling the vegetation composition), broad *Tecticornia* complexes have been described based on the dominant *Tecticornia* taxa and field observations. The workings are shown in Table 9.22 and are discussed below for each lake.

Lake Way: Millipede and Centipede

Two broad *Tecticornia* complexes were delineated at Lake Way: T3 and T4 (Table 9.22 and Figure 9.25).

T3: The section in the north of Millipede and based on opportunistic collections by Ecologia, most of Centipede, incorporates the edge of the main lake bed and has ten statistically distinct *Tecticornia* units recorded. Within these ten units, the most abundant units (T-F and T-HA) each represent 28% of the quadrats sampled (Table 9.22) which have therefore been combined and mapped as one complex: T3 (*Tecticornia* sp. Dennys Crossing (K.A. Shepherd & J. English KS 552) (+/-*T. indica*, *T.* sp. aff. *undulata* (broad articles), *T.* sp. aff *globulifera* (small) and *Tecticornia* sp. Sunshine Lake (K.A. Shepherd *et al.* KS 867)) sparse low shrubland).

T4: The section of Lake Way to the south of the Millipede deposit incorporates vegetation units associated with a small tributary that runs from the main lake bed. Four statistically distinct *Tecticornia* vegetation units were recorded with the most abundant unit (T-BB) recorded at 50% of the quadrats surveyed in this area (Table 9.22) which have therefore been combined and mapped as one complex: T4 (*Tecticornia* sp. Burnerbinmah (D. Edinger *et al.* 101) and *Tecticornia* sp. aff *globulifera* (small) (+/-*T. indica* subsp. *leiostachya* and *Tecticornia* aff *halocnemoides* s.l. 'large ovate seed aggregate') sparse low shrubland).

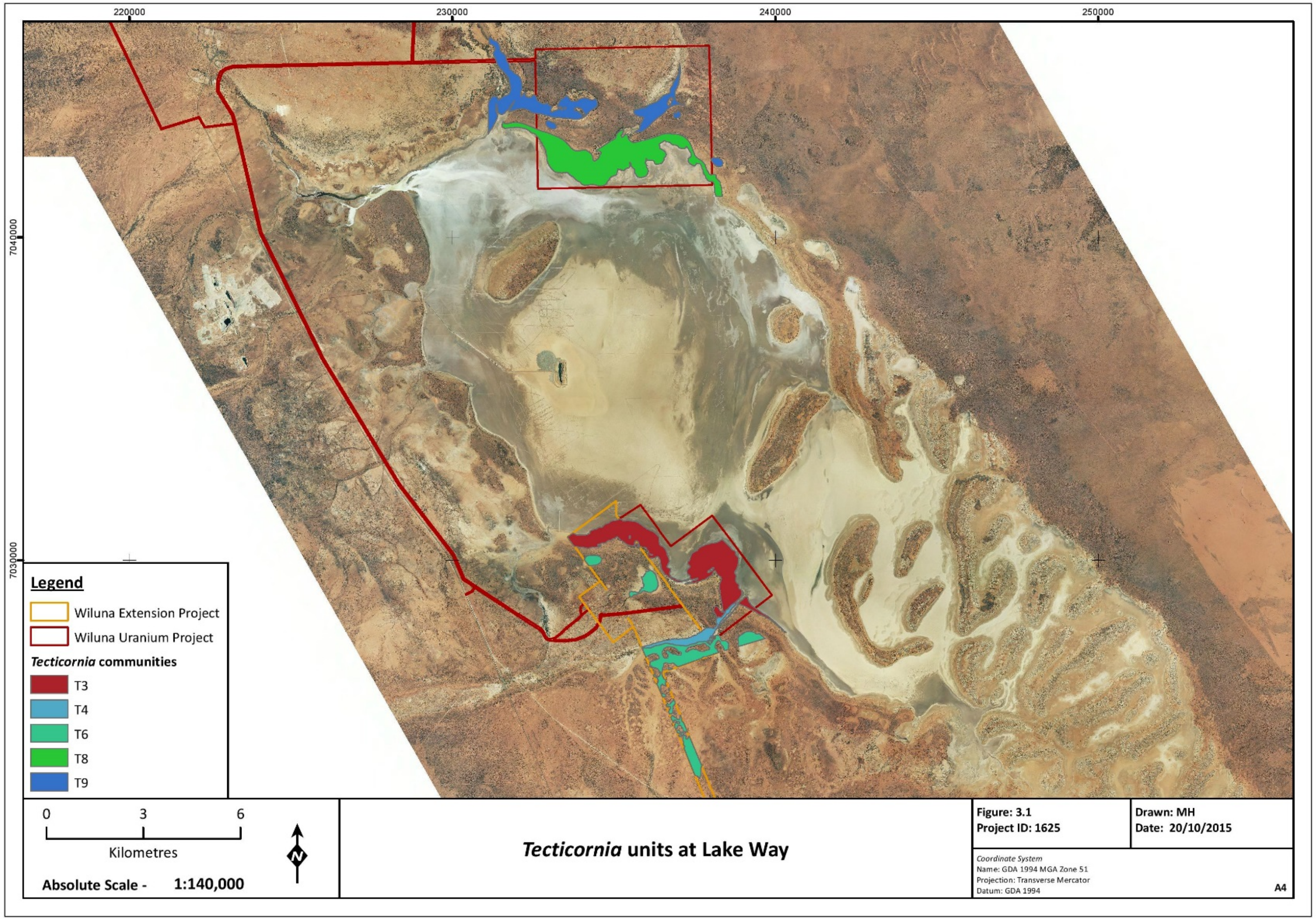
Table 9.22: Mapped *Tecticornia* communities

Location	Mapped unit	*Tecticornia* Units from stats	Unit description from statistical analysis	# quadrats	Unit based on dominant *Tecticornia* taxa within quadrats
Lake Way	**T3**	**T-F**	*Tecticornia* sp. Dennys Crossing (K.A. Shepherd & J. English KS 552) (+/-*T. indica* subsp. *leiostachya* & *T.* sp. aff. *undulata* (broad articles)), over *Eragrostis falcata* isolated tussock grasses	**8**	*Tecticornia* sp. Dennys Crossing (K.A. Shepherd & J. English KS 552) (+/-*T. indica*, *T.* sp. aff. *undulata* (broad articles), *T.* sp. aff *globulifera* (small) and *Tecticornia* sp. Sunshine Lake (K.A. Shepherd *et al.* KS 867)) sparse low shrubland.
		T-HA	*Tecticornia* sp. Dennys Crossing (K.A. Shepherd & J. English KS 552) (+/-T. sp. aff. *undulata* (broad articles, *T.* sp. aff *globulifera* (small) and *T. indica* subsp. *leiostachya)* and *Sclerolaena clelandii*	**8**	
		T-L	*Tecticornia peltata* (+/-*T.* sp. aff *globulifera* (small) and *T.* sp. Sunshine Lake (K.A. Shepherd *et al.* KS 867) sparse low shrubland, over *Eragrostis falcata* isolated tussock grasses	**3**	
		T-GA	*Tecticornia pterygosperma* subsp. *denticulate* and *T.* sp. aff. *undulata* (broad articles) sparse low shrubland (+/-*Mariana pyramidata*)	**2**	
		T-K	*Tecticornia* sp. Sunshine Lake (K.A. Shepherd *et al.* KS 867) sparse shrubland	**2**	
		T-IA	*Tecticornia* sp. aff *laevigata* (non-rotated fruitlets) (+/-*T. laevigata*) and *Maireana luehmannii* sparse low shrubland, over *Eragrostis falcata* isolated tussock grasses	**2**	
		T-GB	*Tecticornia* sp. aff *globulifera* (small), *Lawrencia helmsii* and *Scaevola collaris* (+/-T. sp. Burnerbinmah (D. Edinger *et al.* 101), *T.* sp. aff *laevigata* (non-rotated fruitlets) and *T. indica* subsp. *leiostachya*) sparse low shrubland	**1**	
		T-HB	*Lawrencia helmsii, Sclerolaena clelandii* and *Sclerolaena fimbriolata* (+/-*Tecticornia* sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)) sparse low shrubland, over *Eragrostis falcata* isolated tussock grasses	**1**	
		T-IC	*Tecticornia* sp. Sunshine Lake (K.A. Shepherd *et al.* KS 867) *T.* sp. aff *laevigata* (non-rotated fruitlets) sparse low shrubland	**1**	
		T-E	*Tecticornia* sp. Dennys Crossing (K.A. Shepherd & J. English KS 552) and *Muellerolimon salicorniaceum* sparse low shrubland	**1**	
	T4	**T-BB**	*Tecticornia* sp. Burnerbinmah (D. Edinger *et al.* 101) and/or *T. indica* subsp. *leiostachya* sparse low shrubland, with *Sclerolaena cuneata* scattered low shrubs	**5**	*Tecticornia* sp. Burnerbinmah (D. Edinger *et al.* 101) and *Tecticornia* sp. aff *globulifera* (small) (+/-*T. indica* subsp. *leiostachya* and *Tecticornia* aff *halocnemoides* s.l. 'large ovate seed aggregate') sparse low shrubland.
		T-BA	*Tecticornia* sp. aff *globulifera* (small) sparse low shrubland	**2**	

Location	Mapped unit	*Tecticornia* Units from stats	Unit description from statistical analysis	# quadrats	Unit based on dominant *Tecticornia* taxa within quadrats
		T-L	*Tecticornia peltata* (+/-*T.* sp. aff *globulifera* (small) and *T.* sp. Sunshine Lake (K.A. Shepherd *et al.* KS 867) sparse low shrubland, over *Eragrostis falcata* isolated tussock grasses	**2**	
		T-E	*Tecticornia* sp. Dennys Crossing (K.A. Shepherd & J. English KS 552) and *Muellerolimon salicorniaceum* sparse low shrubland	**1**	
Lake Maitland	**T1**	**T-JA**	*Tecticornia laevigata*, *T.* sp. aff *globulifera* (small) and *T.* sp. aff. *undulata* (broad articles) sparse low shrubland (+/- *Lawrencia densiflora*), over *Eragrostis falcata* sparse tussock grassland	**23**	*Tecticornia laevigata, T.* sp. aff *globulifera* (small) and *T.* sp. aff. *undulata* (broad articles) sparse low shrubland.
		T-JB	*Tecticornia* sp. aff *globulifera* (small) and *T.* sp. aff. *undulata* (broad articles) (+/-*T. peltata* and *T.* aff *halocnemoides* s.l. 'large ovate seed aggregate'), over *Eragrostis falcata* isolated tussock grasses	**3**	
		T-GB	*Tecticornia* sp. aff *globulifera* (small), *Lawrencia helmsii* and *Scaevola collaris* (+/-T. sp. Burnerbinmah (D. Edinger *et al.* 101), *T.* sp. aff *laevigata* (non-rotated fruitlets) and *T. indica* subsp. *leiostachya*) sparse low shrubland	**2**	
		T-IA	*Tecticornia* sp. aff *laevigata* (non-rotated fruitlets) (+/-*T. laevigata*) and *Maireana luehmannii* sparse low shrubland, over *Eragrostis falcata* isolated tussock grasses	**2**	
		T-HA	*Tecticornia* sp. Dennys Crossing (K.A. Shepherd & J. English KS 552) (+/-T. sp. aff. *undulata* (broad articles, *T.* sp. aff *globulifera* (small) and *T. indica* subsp. *leiostachya)* and *Sclerolaena clelandii*	**1**	
		T-HB	*Lawrencia helmsii, Sclerolaena clelandii* and *Sclerolaena fimbriolata* (+/- *Tecticornia* sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)) sparse low shrubland, over *Eragrostis falcata* isolated tussock grasses	**1**	
	T2	**T-L**	*Tecticornia peltata* (+/-*T.* sp. aff *globulifera* (small) and *T.* sp. Sunshine Lake (K.A. Shepherd *et al.* KS 867) sparse low shrubland, over *Eragrostis falcata* isolated tussock grasses	**12**	*Tecticornia peltata*, *T.* sp. aff *globulifera* (small), *T.* sp. aff. *undulata* (broad articles) and *T.* sp. Sunshine Lake (K.A. Shepherd *et al.* KS 867) sparse low shrubland.
		T-JB	*Tecticornia* sp. aff *globulifera* (small) and *T.* sp. aff. *undulata* (broad articles) (+/-*T. peltata* and *T.* aff *halocnemoides* s.l. 'large ovate seed aggregate'), over *Eragrostis falcata* isolated tussock grasses	**9**	
		T-GB	*Tecticornia* sp. aff *globulifera* (small), *Lawrencia helmsii* and *Scaevola collaris* (+/-T. sp. Burnerbinmah (D. Edinger *et al.* 101), *T.* sp. aff *laevigata* (non-rotated fruitlets) and *T. indica* subsp. *leiostachya*) sparse low shrubland	**4**	
		T-K	*Tecticornia* sp. Sunshine Lake (K.A. Shepherd *et al.* KS 867) sparse shrubland	**3**	

Location	Mapped unit	*Tecticornia* Units from stats	Unit description from statistical analysis	# quadrats	Unit based on dominant *Tecticornia* taxa within quadrats
		T-BA	*Tecticornia* sp. aff *globulifera* (small) sparse low shrubland	**3**	
		T-F	*Tecticornia* sp. Dennys Crossing (K.A. Shepherd & J. English KS 552) (+/-*T. indica* subsp. *leiostachya* & *T.* sp. aff. *undulata* (broad articles)), over *Eragrostis falcata* isolated tussock grasses	**3**	
		T-IC	*Tecticornia* sp. Sunshine Lake (K.A. Shepherd *et al.* KS 867) *T.* sp. aff *laevigata* (non-rotated fruitlets) sparse low shrubland	**1**	

Figure 9.25: *Tecticornia* units at Lake Way (Millipede/Centipede)



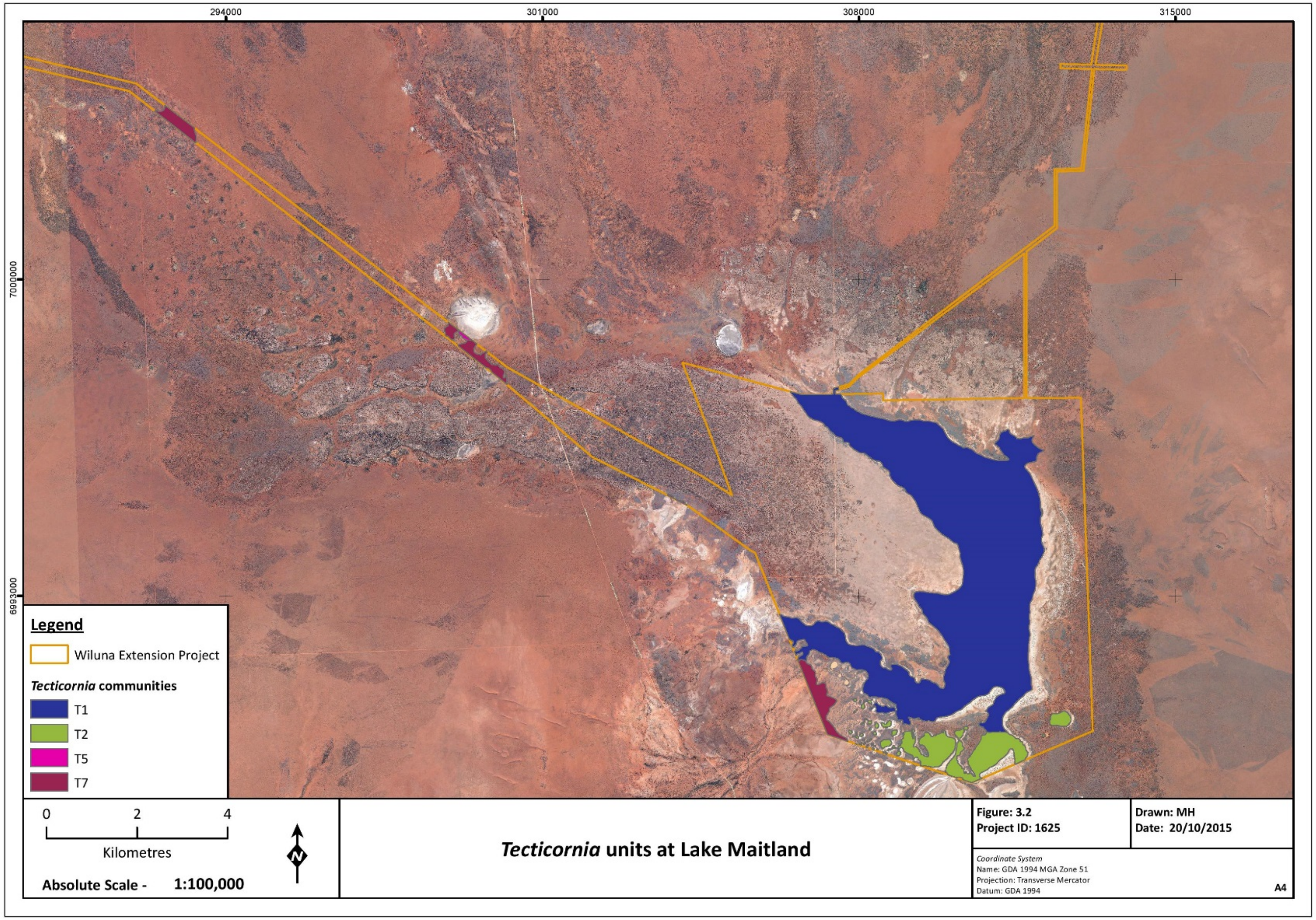
Lake Maitland

Two broad *Tecticornia* communities were delineated at Lake Maitland: T1 and T2 (Table 9.22 and Figure 9.26).

T1: The northern section of Lake Maitland incorporates the main lake bed with six statistically distinct *Tecticornia* vegetation units recorded. Within these six vegetation units, the most abundant unit (T-JA) was recorded at 72% of the quadrats in this area. Based on the most dominant *Tecticornia* taxa as well as field observations, the main lake bed has been mapped as one complex: T1 (*Tecticornia laevigata, T.* sp. aff *globulifera* (small) and *T.* sp. aff. *undulata* (broad articles) sparse low shrubland) (Table 9.22).

T2: The southern section of Lake Maitland incorporates a trail of smaller salt pans that runs south from the main lake bed for approximately 30 km. Seven statistically distinct *Tecticornia* vegetation units were recorded and the two most abundant units (TJ-B and T-L) were recorded at 34% and 26% of the quadrats in this area, respectively. These statistically-defined units are very similar in species composition and have therefore been mapped as one complex: T2 (*Tecticornia peltata*, *T.* sp. aff *globulifera* (small), *T.* sp. aff. *undulata* (broad articles) and *T.* sp. Sunshine Lake (K.A. Shepherd *et al.* KS 867) sparse low shrubland) (Table 9.22). As there was more dissimilarity in the statistical analysis of the quadrats in this area, it is likely to represent a higher variation of communities in these smaller salt pan areas.

Figure 9.26: Tecticornia units at Lake Maitland



Vegetation Consolidation (Ecologia, 2015g - Appendix 10.49)

During the analysis for the vegetation consolidation (Ecologia, 2015g – Appendix 10.49), all *Tecticornia* spp. were combined, as the identifications from all surveys are not consistent. Four *Tecticornia* dominated vegetation units were delineated based on the cluster analysis:

- S: *Tecticornia* spp., *Frankenia cinerea*, *Maireana villosa* and *Atriplex amnicola* sparse low shrubland;
- T: *Tecticornia* spp., *Cratystylis subspinescens* and *Scaevola spinescens* sparse low shrubland;
- U: *Tecticornia* spp., *Maireana amoena* and *Scaevola collaris* sparse low shrubland, over *Eragrostis lanipes* sparse tussock grassland; and
- V: *Cratystylis subspinescens*, *Maireana amoena* and *Sclerolaena diacantha* (+/-*Tecticornia indica*, *Tecticornia laevigata*, *Tecticornia disarticulata*) sparse mid shrubland, over *Eragrostis falcata* sparse tussock grassland.

As the dominant species for these communities (*Tecticornia*) were combined under one taxon (*Tecticornia* sp.) in the data analysis, these units do not reflect the individual *Tecticornia* taxa present within the quadrats.

Haul Road (Ecologia 2015a - Appendix 10.36)

The analysis for the haul road was conducted with all *Tecticornia* spp. combined under one taxon *Tecticornia* sp.), therefore these units do not reflect the individual *Tecticornia* taxa present within the quadrats. Based on the dominant *Tecticornia* taxa subsequently identified within quadrats as well as field observations, it is considered that three additional *Tecticornia* complexes occur within the haul road study area:

- T5: *Melaleuca xerophila* mid sparse shrubland, over *Tecticornia cymbiformis*, *Dissocarpus paradoxus* and *Frankenia laxiflora* low shrubland, over *Enneapogon caerulescens* and *Eragrostis dielsii* sparse tussock grassland;
- T6: *Frankenia fecunda* (glabrous leaf variant) and *Tecticornia disarticulata* (+/-*Tecticornia indica* subsp. *bidens*) low sparse shrubland, over *Aristida holathera* and *Eragrostis falcata* sparse tussock grassland; and
- T7: *Cratystylis subspinescens*, *Maireana amoena* and *Sclerolaena diacantha* (+/-*Tecticornia laevigata* and/or *Tecticornia disarticulata*) sparse mid shrubland, over *Eragrostis falcata* sparse tussock grassland.

Lake Way Deposit (Niche 2011a - Appendix 10.12)

Niche (2011a – Appendix 10.12) identified two *Tecticornia* communities at the Lake Way deposit. The *Tecticornia* taxa listed in these descriptions are based on the identifications presented in the *Tecticornia* review by Actis (2012 - Appendix 10.61). Cover scores were not presented in this report, so all *Tecticornia* taxa recorded in each complex are listed below and it is not known which form the dominant species.

- T8: *Tecticornia* spp. (*Tecticornia indica* subsp. *bidens, Tecticornia* sp. aff *pruinosa*, *Tecticornia laevigata, Tecticornia* sp. aff. *undulata, Tecticornia peltata* and *Tecticornia* sp. (*halocnemoides* beaked seed aggregate) sparse low shrubland; and

- T9: *Acacia victoriae* and *Melaleuca xerophila* scattered tall shrubs, over *Lycium australe* and *Cratystylis subspinescens* sparse mid shrubland, over *Tecticornia* spp. (*Tecticornia indica* subsp. *bidens, Tecticornia* sp. aff *pruinosa*, *Tecticornia laevigata*, *Tecticornia* sp. aff. *undulata*, *Tecticornia peltata* and *Tecticornia* sp. (*halocnemoides* beaked seed aggregate) sparse low shrubland.

Summary of Tecticornia Complexes

Nine non-statistically delineated *Tecticornia* complexes are thought to be present across the Project area. They are listed in Table 9.23 and mapped on Figure 9.25 for Lake Way and Figure 9.26 for Lake Maitland.

Table 9.23: *Tecticornia* complexes at the study area

Complex	Description	Location
T1	*Tecticornia laevigata, T.* sp. aff *globulifera* (small) and *T.* sp. aff. *undulata* (broad articles) sparse low shrubland.	Lake Maitland, main lake bed (1,819 ha).
T2	*Tecticornia peltata*, *T.* sp. aff *globulifera* (small), *T.* sp. aff. *undulata* (broad articles) and *T.* sp. Sunshine Lake (K.A. Shepherd *et al.* KS 867) sparse low shrubland.	Lake Maitland, trail of small salt pans running south (188 ha).
T3	*Tecticornia* sp. Dennys Crossing (K.A. Shepherd & J. English KS 552) (+/- *T. indica*, *T.* sp. aff. *undulata* (broad articles), *T.* sp. aff *globulifera* (small) and *Tecticornia* sp. Sunshine Lake (K.A. Shepherd *et al.* KS 867)) sparse low shrubland.	Lake Way, Millipede and Centipede deposits on the main lake bed (405 ha).
T4	*Tecticornia* sp. Burnerbinmah (D. Edinger *et al.* 101) and *Tecticornia* sp. aff *globulifera* (small) (+/-*T. indica* subsp. *leiostachya* and *Tecticornia* aff *halocnemoides* s.l. 'large ovate seed aggregate') sparse low shrubland.	Lake Way, Millipede and Centipede deposits on the minor tributary that runs through the south (53 ha).
T5	*Melaleuca xerophila* tall sparse shrubland, over *Tecticornia cymbiformis, Dissocarpus paradoxus,* and *Frankenia laxiflora* low shrubland, over *Enneapogon caerulescens* and *Eragrostis dielsii* sparse tussock grassland.	Haul Road to the west of Lake Maitland. Bordering the small salt pan (2 ha).
T6	*Frankenia fecunda* (glabrous leaf variant) and *Tecticornia disarticulata* (+/- *Tecticornia indica* subsp. *bidens*) low sparse shrubland, over *Aristida holathera* and *Eragrostis falcata* sparse tussock grassland.	Haul Road to the south of the Millipede and Centipede deposits. Recorded from the floodplain area (239 ha).
T7	*Cratystylis subspinescens*, *Maireana amoena* and *Sclerolaena diacantha* (+/-*Tecticornia laevigata* and *Tecticornia indica*) sparse mid shrubland, over *Eragrostis falcata* sparse tussock grassland.	Haul Road to the west of Lake Maitland. Recorded from a floodplain area (102 ha).
T8^	*Tecticornia* spp. (*Tecticornia indica* subsp. *bidens, Tecticornia* sp. aff *pruinosa*, *Tecticornia laevigata, Tecticornia* sp. aff. *undulata, Tecticornia peltata* and *Tecticornia* sp. (*halocnemoides* beaked seed aggregate) sparse low shrubland.	Lake Way, Lake Way deposit. Recorded on the main lake bed (447 ha).
T9^	*Acacia victoriae* and *Melaleuca xerophila* scattered tall shrubs, over *Lycium australe* and *Cratystylis subspinescens* sparse mid shrubland, over *Tecticornia* spp. (*Tecticornia indica* subsp. *bidens, Tecticornia* sp. aff *pruinosa*, *Tecticornia laevigata*, *Tecticornia* sp. aff. *undulata*, *Tecticornia peltata* and *Tecticornia* sp. (*halocnemoides* beaked seed aggregate) sparse low shrubland.	Lake Way, Lake Way deposit. Recorded on the minor tributaries that are further away from the lake bed (306 ha).

Notes: ^ = Recorded by Niche 2011a (Appendix 10.12) and Actis 2012 (Appendix 10.61).

9.5 Potential Impacts

9.5.1 Mitigation Hierarchy

The mitigation hierarchy has been considered to reduce impacts to flora and vegetation. Table 9.24 describes how the mitigation hierarchy has been applied.

Table 9.24: Mitigation hierarchy for management of flora and vegetation

Potential Impact	Mitigation Approach	Details
Clearing of Native Vegetation	Minimise and rehabilitate	Key infrastructure such as the processing plant would be shared between Millipede and Lake Maitland reducing the overall need for clearing. Mining areas have been well defined and Toro would use efficient surface mining techniques to ensure only target areas need to be disturbed.
Changes to Surface Hydrology	Reduce/minimise	Surface flows would be diverted around key infrastructure and reinstated downstream. Environmental culverts along the haul road alignment would ensure no rain shadow effects downstream of the haul road.
Groundwater Drawdown	Minimise	Water barriers around mining pits would be installed to reduce the need for abstraction. This would have a flow-on effect of reducing drawdown around mining areas.
Radionuclide Impacts on Vegetation	Reduce/minimise	An ERICA assessment has been undertaken which shows that under normal operating conditions the impacts of radionuclides on vegetation would be minimal. Through the use of dust controls such as water carts on haul roads, handling wet or damp ore and dust control at the plant, the impacts on vegetation can be reduced to negligible amounts.

9.5.2 Clearing

The Proposal would result in the disturbance of just over 1580 ha of land to construct the infrastructure required for mining and ore haulage. The extent of the clearing to enable the Proposal to be implemented, when put into a regional context, is low and no significant impacts are predicted. The lack of DRF and low representation of priority species across Millipede and Lake Maitland ensure that these species would not be impacted by the Proposal.

A review of publicly available information on the extent of clearing in the Wiluna region has concluded that almost 100% of the inferred pre-European extent of native vegetation remains, although in places the condition of the vegetation has been heavily impacted by grazing, logging, fire or other threatening processes. While clearing is considered to be negligible, the extent of vegetation formally protected in conservation reserves is low. Of the 17 vegetation units identified by Shepherd *et al*. (2001) within a 50 km radius of Wiluna, eight are not represented in any conservation reserve (Table 9.25).

Table 9.25: Reservation status: vegetation within 50 km radius of Wiluna

System Association Code	Description	Area (ha)	Percent in Reserves[1]
11	Medium woodland; coolabah (*Eucalyptus microtheca*)	6986	0
18	Low woodland; mulga (*Acacia aneura*)	621,623	3.75
19	Low woodland; mulga between sandridges	875	0
28	Open low woodland; mulga	4527	0
29	Sparse low woodland; mulga, discontinuous in scattered groups	157,951	10
39	Shrublands; mulga scrub	102,773	2.4
40	Shrublands; *Acacia* scrub, various species	1116	0.63
107	Hummock grasslands, shrub steppe; mulga and *Eucalyptus kingsmillii* over hard spinifex	494,618	8
125	Bare areas; salt lakes	25,167	1.3
188	Shrublands; mulga & *Acacia sclerosperma* scrub	3634	0
202	Shrublands; mulga & *Acacia quadrimarginea* scrub	31,400	0
204	Succulent steppe with open scrub; scattered mulga & *Acacia sclerosperma* over saltbush & bluebush	51,202	0
389	Succulent steppe with open low woodland; mulga over saltbush	7884	.2
560	Mosaic; shrublands; bowgada scrub/succulent steppe; samphire	17,029	0
561	Succulent steppe with low woodland; mulga over saltbush	5098	0
676	Succulent steppe; samphire	4112	15.5
1271	Bare areas; claypans	3131	0

Source: Shepherd et al. (2001)
Note: 1. The 'percent reserved' figures are for the entire Wiluna LGA.

Information gathered during regional surveys was used to assist with placing the vegetation and flora in the proposed disturbance areas at Millipede into context. The dunes, plains and calcrete vegetation within the area surveyed to study the impacts of the Proposal were similar to vegetation found during regional surveys (Niche Environmental Services, 2011a – Appendix 10.12).

A number of the regional systems surveyed were noted as having different substrates or structural characteristics, or both, in comparison to those in the study area. The Lake King system, located approximately 100 km north of Lake Way, was noted as being the system that bore the greatest structural and substrate similarity to the *Tecticornia* vegetation within the study area.

Dr K Shepherd from the WAH was consulted in relation to the conservation value attached to *Tecticornia* spp. vegetation. Dr Shepherd noted that (apart from Toro's work) surveys of *Tecticornia* vegetation in the Wiluna region and surrounds were limited, in terms of intensity and scale, and further survey work was likely to be required to clarify the degree of relationship between samphire assemblages within and between lake systems. Ecologia was commissioned to undertake further suveys across Millipede and Lake Maitland, both inside and outside of proposed disturbance areas, to outline *Tecticornia* communities and collect further specimens for identification. These specimens were identified by Ecologia botanists and referred to the WAH for confirmation of identification (Ecologia, 2015e – Appendix 10.7).

The work undertaken by Ecologia and the WAH has demonstrated that the distribution of *Tecticornia* species occurs over a wide range, with both lakes sharing a considerable numbers of species. Therefore, while it is likely that there would be impacts from implementation of the Proposal to currently undescribed species, the range of these species is likely to be greater than initially thought and further survey work to be specified in the *Tecticornia* Survey and Research Plan to be undertaken by Toro in consultation with DPaW is likely to confirm this.

The impacts to individual bush tucker species from proposed mining at Millipede were considered to be minimal, with all species recorded during the survey noted as not having conservation significance and being either locally common or widespread in Western Australia (Toro Energy, 2011a – Section 5.6.5).

Of the 27 bush tucker species identified by the Barwidgee People at Lake Maitland, 18 were also identified in previous baseline surveys in the region. The Barwidgee People have advised Toro that they do not believe that the Proposal would have any adverse impact on their access or ability to continue to gather bush tucker. To consider measures to avoid or minimise disturbance of bush tucker species, Toro proposes, in further consultation with the Barwidgee People, to:

- Prior to the commencement of mining, establish control sites and replicates of each species, including:
  - Within the ore body;
  - Upwind of prevailing winds; and
  - In regional locations.
- Establish monitoring sites downwind of the prevailing wind direction and at various distances from operations;
- Collect soil samples from each monitoring location;
- Conduct biannual monitoring in autumn and spring to capture varying wind directions, and to account for the various flowering and seeding times of rain-responsive plants; and
- Consider the timing of monitoring surveys with the availability of bush tucker, e.g. fruits, nuts and seeds (Golder Associates, 2011h).

Along the haul road, no species of significance (EPBC Act or EP Act) were recorded within the study area (Ecologia, 2015a – Appendix 10.36). Along the haul road, two priority species were identified. The two priority species recorded have moderate to large ranges and have been recorded previously around the study area, so are therefore not considered to be regionally significant (Ecologia, 2015a - Appendix 10.36). Four range extensions have been recorded as part of the haul road survey. *Acacia heteroneura* var. *jutsonii*, *Paspalidium gracile*, *Pterocaulon sphacelatum* and *Frankenia* sp. aff. *fecunda* have locations on Florabase that are scattered around Western Australia, and within the Murchison region. *Mollugo cerviana* and *Thyridolepis xerophila* also have locations on Florabase that are scattered around the State, but not within the Murchison region. These distribution patterns suggest they are widespread, but poorly vouchered and therefore these taxa are not considered regionally significant (Ecologia, 2015a – Appendix 10.36).

At Lake Maitland, vegetation was not considered to be regionally significant, and the survey area did not incorporate a large proportion of any given broad vegetation type. Casurina and eucalypt woodlands found on the calcrete vegetation appear to be more restricted across the broader region. However, given the relatively small access route, accommodation camp and borefield, it is unlikely that they would be significantly impacted by the development.

9.5.3 Changes to Surface Hydrology

Changes to surface hydrology have the potential to redirect surface water flows and may lead to changes in vegetation unit composition in areas impacted as part of this Proposal. The impacts could include:

- Interruption to existing surface water flow patterns;
- Reduction of surface water runoff volume and quality in water courses downstream;
- Impact on downstream vegetation communities that may depend on upstream flows;
- Discharge of chemicals, including hydrocarbons or reagents; and
- Pooling of water, growth of invasive species in low lying areas (requiring attention to the location and design of roads, sediment basins and other infrastructure).

Impacts associated with the installation of the haul road are likely to be low, given the relatively short period the haul road would be in existence (~six years). Pre-construction engineering studies will identify locations for environmental culverts that would be used to ensure sheet flows remain as close to pre-mining conditions as possible. This will ensure that impacts to downstream vegetation are negligible. After use, the road would be rehabilitated in accordance with the Mine Closure and Rehabilitation Plan, leading to a return in natural flows.

At the Millipede and Lake Maitland mining locations, the lakes provide a terminus for surface water flows. Upstream of the lakes, there would be no changes to surface water flows. Changes would only occur on the margins of the lakes at the mining locations and at the processing plant site adjacent to Millipede. Across the two deposits, the main vegetation impacted would be lake *Tecticornia* species. These species need damp soils for a period of three months at a frequency of at least once every three years (Doeg *et al.,* 2012). Groundwater or surface water from flows are unlikely to be a sufficient source. The more likely source is the heavy rainfall period in the region from October to April. In areas where groundwater is drawn down, it is likely that the moist soils present during the rain season are sufficient to ensure the continuity of individuals, communities and populations.

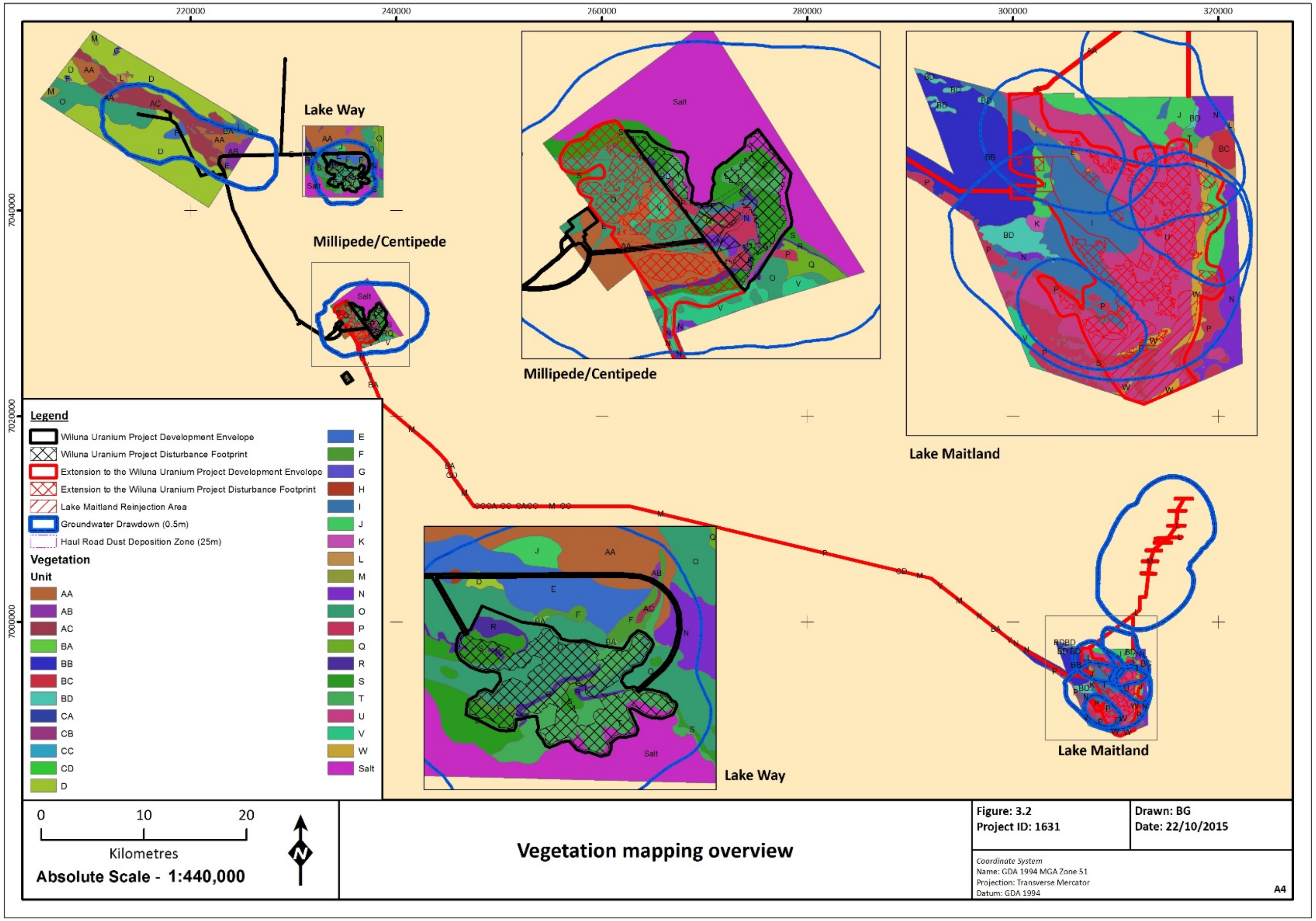
To provide a greater understanding of *Tecticornia,* Toro would implement a *Tecticornia* Survey and Research Plan to assess *Tecticornia* species in greater detail, including their ecophysiological aspects. As implementation of this plan would commence prior to mining, it is likely that information on the environmental requirements of these species would be gained early in the life of the Proposal. This information would be used to enhance vegetation and groundwater drawdown management plans, so that impacts on vegetation are reduced.

9.5.4 Groundwater Drawdown

Groundwater drawdown has the potential to impact vegetation, particularly groundwater dependent vegetation, by reducing the availability of water. Figure 9.27 shows vegetation units and groundwater drawdown cones. Toro has undertaken hydrology studies to assess the impacts of this drawdown and has nominated the 0.5 m drawdown contour as the battery limit for impacts from the Project (RPS, 2014a – Appendix 10.31). Toro has committed to installing groundwater barriers around mine pits, to reduce the volume of water to be required, and has developed a drawdown management plan which specifies the actions to be taken if groundwater drawdown is greater than the model predicts. The possibility of this occurring is considered to be low as water barrier studies conducted in the field have shown up to 80% reductions in water ingress into pits (Toro, 2011b).

Inside the 0.5 m drawdown contour there are expected to be impacts on vegetation, especially groundwater dependent vegetation. As noted above, some species require groundwater which is shallow enough to keep soils damp for periods of at least three months on a frequency of at least once every three years (Doeg *et al.,* 2012).

Figure 9.27: Vegetation mapping overview with groundwater drawdown



To assess potential impacts on vegetation outside the 0.5 m drawdown contour, Toro has undertaken regional groundwater monitoring on a monthly basis since 2010. At each bore, the depth to water is recorded to assess how groundwater depth changes over time. Table 9.26 shows the monthly depth to water in 2012 at two bores located near the Millipede deposit. The North Shallow Bore is located on the northern extent of the Millipede tenement M53/1095 on the Lake Way playa, while the South Shallow Bore is located in rear dunes on tenement M53/224. The table shows that throughout the year depths to groundwater vary greatly, and on the lake there is a 100% increase in depth to water throughout the year. This is likely to be due to storm events that lead to an increase in waters reaching the lake.

In the rear dune areas, which are slightly elevated from the lake surface, there is also significant change in groundwater depth over the year. In the months preceding significant rainfall, the depth to groundwater falls by 76 cm or nearly 16%. The ability of plants to adapt to these changes in groundwater level indicates that they are tolerant to regional changes in groundwater depth.

Table 9.26: Monthly depth to groundwater – Millipede

Month	Depth to Water North Shallow Bore (mbgl)	Depth to Water South Shallow Bore (mbgl)
January	1.0	4.5
February	2.0	4.3
March	1.85	4.25
April	1.65	4.18
May	1.9	4.3
June	1.8	4.15
July	1.8	4.29
August	2.0	4.49
September	1.85	4.65
October	1.85	4.70
November	1.60	4.86
December	1.80	4.10

At Millipede, Toro is committed to maintaining vegetation health outside the already assessed 0.5 m drawdown contour as established in EPA Assessment 1819. This would be achieved through the use of water barriers around mining pits and through managing and staging groundwater abstraction as required. At Lake Maitland, groundwater flows in the region are towards the lake from all directions (Pennington Scott, 2015b – Appendix 10.30). The management of impacts on flora and vegetation communities would be achieved through the reinjection borefield and implementation of the Groundwater Management Plan. The proposal for reinjection can be managed to negate the impacts of mine dewatering drawdown as much as possible (Pennington Scott, 2015b – Appendix 10.30). If actual drawdown began to exceed modelled drawdown, reinjection would be directed to those areas with less water. Waters inside the 0.5 m drawdown contour are saline and so the reinjection of saline mine dewatering water would be a suitable replacement for the groundwater (Golder Associates, 2011c).

9.5.5 Impacts of Radiation on Vegetation

Toro undertook additional ERICA modelling to assess the impacts of increased dust, and therefore increased radionuclides in soils (Appendix 10.34). The model accepted that inside mining areas the increase of radionuclides would be high, but that all vegetation inside mining areas would be disturbed by mining activities.

The model instead focussed on the sections of the mining leases that would not be affected by mining. The modelling assumed soil radionuclide concentrations of 35.5 Bq/kg at Millipede and 12 Bq/kg at Lake Maitland, equivalent to the 1 g/m^2/month dust contour (representative of the extents of the mining area). After taking into account published literature on the radiosensitivity of lichen and bryophytes, the risk of radiological harm was assessed as 'negligible' for all reference organisms.

It is noted that the ERICA assessment is a tool that assesses the risk for a range of reference organisms both inside and outside of the food chain. The ERICA assessment is discussed further in section 14.7.6 of the PER.

9.5.6 Best and Worst Case Impacts of Land Disturbance

The configuration of the Proposal, including infrastructure and the haul road between Lake Maitland and the processing plant, would require just over 1580 ha of land disturbance. This represents a worst case scenario.

During the Definitive Feasibility Study for the Proposal, Toro would seek to reduce the area of disturbance and would also take into account the location of priority flora species and *Tecticornia* vegetation in finalising areas to be disturbed for the establishment of roads and other infrastructure.

Toro has undertaken rehabilitation trials across two previously excavated costeans using seeding and various land treatments. These trials are continuing, but it is evident already that vegetation communities are recovering. This is in addition to the work Toro would fund and support under a *Tecticornia* Survey and Research Plan to re-establish vegetation communities and conservation significant taxa in disturbed areas.

9.6 Impact Management

The key actions required to manage impacts to flora and vegetation as a result of implementation of the Proposal are:

- Minimising clearing by positioning temporary disturbance (lay down areas, stockpiles, sediment ponds and the like) along the planned mine path;
- Controlling groundwater drawdown through the use of vertical barriers around the pit voids;
- Limiting dust generation by clearing progressively and closely integrating clearing and rehabilitation schedules;
- Strictly enforcing and monitoring of groundwater abstraction limits;
- Implementing weed hygiene and surveillance measures throughout the construction and operational phases; and
- Further investigating the taxonomy, ecology and environmental water requirements of *Tecticornia* communities.

9.7 Cumulative Impacts

Toro commissioned Ecologia to undertake a Cumulative Impact Assessment (CIA) of the Wiluna Uranium Project and its Extension (Ecologia, 10.50 – Appendix 2015h). For the purposes of the CIA, the impact area has been defined as the 'disturbance footprint' and the worst case scenario has been identified as the 'development envelope'. Indirect impacts were also calculated and include groundwater drawdown on *Tecticornia* species notwithstanding that there is little evidence to demonstrate that any of the *Tecticornia* species present are groundwater dependent. Impacts from dust along the haul road between Lake Maitland and the processing plant are included as indirect impacts. Table 9.27 is a summary of Project impacts.

Table 9.27: Summary of project impacts on vegetation (ha)

Extension to the Wiluna Uranium Project								Wiluna Uranium Project – clearing extent authorised	Cumulative Project total
Extent within development envelope				Extent within disturbance footprint					
Millipede	Haul Road	Lake Maitland	Lake Maitland Borefield	Millipede	Haul Road	Lake Maitland	Lake Maitland Borefield		
739.0	304.2	2,824	23.6	537.9	243.9	800.0	23.6	1,530.0	3,111.8
3,890.8				1,581.8					

Information from the following study reports was used in assessing cumulative impacts on flora and vegetation:

- Outback Ecology (2007a – Appendix 10.58): Lake Way and Centipede baseline vegetation and flora survey;
- Outback Ecology (2009b – Appendix 10.17): Lake Maitland: baseline vegetation and flora surveys;
- Niche Environmental (2011a – Appendix 10.12): Assessment of the flora and vegetation of Lake Way, Centipede and West Creek Borefield;
- Niche Environmental (2014 – Appendix 10.13): Assessment of the flora and vegetation of Millipede;
- Ecologia (2015a – Appendix 10.36): Millipede to Lake Maitland Haul Road Level 2 flora and vegetation assessment;
- Ecologia (2015g – Appendix 10.49): Flora and Vegetation Consolidation
- Ecologia (2015h – Appendix 10.50): Cumulative Impact Assessment; and
- Ecologia (2015e – Appendix 10.7): Assessment of *Tecticornia* communities associated with Lake Way and Lake Maitland

Survey results from baseline mapping described in these reports were consolidated to enable the combined impacts of Toro's proposed activities to be assessed (Appendix 10.50).

9.7.1 Vegetation

A total of 31 vegetation units have been consolidated and mapped in the Project area (Ecologia 2015g – Appendix 10.49). Vegetation units are described in Table 9.28 and are mapped in Figure 9.28 to Figure 9.31.

Direct Impacts – Vegetation

The direct impacts of the Wiluna Uranium Project and the Extension to the Wiluna Uranium Project to vegetation are outlined in Table 9.29. Direct impacts are defined here as the area approved for clearing under the Wiluna Uranium Project and the proposed disturbance footprint for the Extension to the Wiluna Uranium Project (although impacts for the development envelope for the Extension to Wiluna Uranium Project are also included). Mapping of vegetation units with impact areas is provided in Figure 9.28 to Figure 9.31.

Indirect Impacts – Vegetation

The indirect impacts of the Wiluna Uranium Project and the Extension to the Wiluna Uranium Project to vegetation units are outlined in Table 9.29. Indirect impacts on vegetation of the Wiluna Uranium Project and the Extension to the Wiluna Uranium Project include the impacts of groundwater drawdown and dust deposition.

Groundwater Drawdown

The indirect impacts due to groundwater abstraction are defined here as the area within the 0.5 m drawdown contours for the Lake Way deposit, Centipede/Millipede deposit, Lake Maitland deposit, West Creek Borefield, and Lake Maitland Borefield components of the Wiluna Uranium Project and its Extension. The extent of each vegetation unit directly impacted is excluded from the calculation of indirect impacts where that vegetation unit indirectly impacted falls within a direct impact zone.

Dust Deposition

The indirect impacts due to dust deposition are defined here as within 25 m either side of the Millipede to Lake Maitland Haul Road. The number of individual plants directly impacted is excluded from the calculation of indirect impacts where those individuals indirectly impacted fall within direct impact zones.

Table 9.28: Vegetation unit descriptions

Unit	Description
AA	*Acacia tetragonophylla* sparse tall shrubland, over *Senna artemisioides* and *Ptilotus obovatus* sparse low shrubland
AB	*Acacia tetragonophylla*, *Acacia victoriae* and *Ptilotus obovatus* sparse low shrubland
AC	*Eucalyptus camaldulensis* subsp. *obtusa* sparse low woodland, over *Acacia aptaneura* and *Acacia tetragonophylla* sparse tall shrubland, over *Eremophila longifolia*, *Senna artemisioides* and *Scaevola spinescens* sparse mid shrubland
BA	*Acacia aneura/aptaneura* sparse low woodland, over *Acacia tetragonophylla* (+/- *Melaleuca hamata*) sparse tall shrubland, over *Senna artemisioides*, *Scaevola spinescens* and *Rhagodia drummondii* sparse mid shrubland, over *Ptilotus obovatus*, *Maireana villosa*, *Sclerolaena diacantha* and *Cratystylis subspinescens* sparse low shrubland
BB	*Casuarina pauper* open low woodland, over *Eremophila pantonii*, *Eremophila longifolia* and *Eremophila latrobei* sparse mid shrubland, over *Scaevola spinescens, Exocarpos aphyllus, Rhagodia drummondii* and *Ptilotus obovatus* sparse low shrubland
BC	*Scaevola spinescens, Eremophila malacoides, Rhagodia drummondii, Maireana villosa* and *Eremophila glabra* sparse low shrubland, over *Enteropogon ramosus* sparse tussock grassland
BD	*Acacia aneura/aptaneura* sparse low woodland, over *Maireana pyramidata, Maireana triptera* and *Atriplex bunburyana* open low shrubland

Unit	Description
CA	*Acacia aneura/aptaneura* sparse low woodland, over *Acacia burkittii* open tall shrubland, over *Eremophila galeata, Eremophila compacta, Senna* sp. *Meekatharra* (E. Bailey 1-26), *Senna artemisioides* and *Sida ectogama* sparse mid shrubland, over *Monachather paradoxus* open tussock grassland
CB	*Acacia aneura/aptaneura* open low woodland, over *Acacia burkittii* and *Acacia tetragonophylla* sparse tall shrubland, over *Senna artemisioides x artemisioides*, *Senna glaucifolia* and *Eremophila galeata* open mid shrubland, over *Aristida contorta* open tussock grassland
CC	*Acacia pteraneura/macraneura* isolated low trees, over *Eremophila galeata, Senna artemisioides* and *Sida ectogama* sparse mid shrubland, over *Eragrostis eriopoda* and *Monachather paradoxus* open tussock grassland
CD	*Acacia aneura/aptaneura, Acacia pteraneura/macraneura* and *Acacia craspedocarpa* low woodland, over *Eremophila gilesii, Eremophila galeata* and *Senna artemisioides* sparse mid shrubland, *over Sida* sp. verrucose glands (F.H. Mollemans 2423), *Solanum lasiophyllum* and *Abutilon cryptopetalum* sparse low shrubland, over *Digitaria brownii, Eragrostis eriopoda* and *Monachather paradoxus* sparse tussock grassland
D	*Acacia aneura/aptaneura/ayersiana/caesaneura* open low woodland (+/-*Acacia tetragonophylla* and *Acacia pruinocarpa*), over *Eremophila forrestii, Eremophila latrobei, Eremophila foliosissima* sparse mid shrubland, over *Eragrostis eriopoda* sparse tussock grassland and *Triodia melvillei* sparse hummock grassland
E	*Acacia aneura/aptaneura/ayersiana/caesaneura* (+/-*Eucalyptus gypsophila*) sparse low woodland, over *Acacia nyssophylla*, *Eremophila arachnoides* subsp. *arachnoides* and *Acacia victoriae* sparse mid to tall shrubland, over *Ptilotus obovatus, Sclerolaena obliquicuspis* and *Rhagodia eremaea* sparse low shrubland, over *Eragrostis eriopoda* sparse tussock grassland
F	+/- *Acacia victoriae* and/or *Melaleuca interioris* sparse tall shrubland, over *Eremophila glabra, Scaevola spinescens, Rhagodia eremaea* and *Lycium australe* sparse low shrubland
G	*Acacia incurvaneura* woodland (+/-*Acacia craspedocarpa* and *Acacia ramulosa* var. *linophylla*), over *Eremophila maculata* and *Scaevola spinescens* shrubland over *Triodia melvillei* open hummock grassland
H	+/- *Eucalyptus striaticalyx* and *Acacia aneura/aptaneura* sparse low woodland, over *Eremophila glabra* and *Senna artemisioides* sparse mid shrubland, over *Dissocarpus paradoxus, Eremophila oppositifolia* and *Sclerolaena bicornis* sparse low shrubland
I	+/- *Acacia aneura/aptaneura* isolated low trees, over *Lycium australe, Rhagodia drummondii, Frankenia pauciflora* sens. lat. and *Lawrencia squamata* open low shrubland
J	+/- *Casuarina pauper* sparse low woodland, over *Atriplex bunburyana, Lycium australe, Lawrencia squamata* and *Ptilotus obovatus* sparse low to mid shrubland, over *Eragrostis setifolia* sparse tussock grassland
K	*Casuarina obesa* open low woodland, over *Acacia nyssophylla* sparse tall shrubland, over *Lycium australe* and *Sclerolaena fimbriolata* sparse low shrubland
L	+/- *Acacia aneura/aptaneura* and *Hakea lorea* subsp. *lorea* isolated low trees, over *Alyogyne pinoniana, Androcalva loxophylla, Solanum coactiliferum* and *Leptosema chambersii* sparse low shrubland, over *Triodia basedowii* open hummock grassland and *Eragrostis eriopoda* sparse tussock grassland
M	*Acacia aneura/aptaneura* (+/-*Acacia ayersiana/caesaneura*) open low woodland, over *Eremophila forrestii, Eremophila spectabilis* subsp. *brevis* open mid shrubland, over *Triodia basedowii* open hummock grassland and *Eragrostis eriopoda* and *Monachather paradoxus* sparse tussock grassland
N	*Acacia ayersiana/caesaneura* open low woodland (+/-*Acacia aneura/aptaneura* and *Eucalyptus eremicola* subsp. *peeneri*) open low woodland, over +/- *Melaleuca interioris* sparse tall shrubland, over *Triodia basedowii* open hummock grassland and *Eragrostis eriopoda* sparse tussock grassland
O	*Acacia ayersiana/caesaneura* open low woodland (+/- *Eucalyptus eremicola* subsp. *peeneri*) open low woodland, over *Triodia melvillei* open hummock grassland
P	+/- *Acacia ayersiana/caesaneura* (+/-*Eucalyptus eremicola* subsp. *peeneri* and *Eucalyptus kingsmillii*) sparse low woodland, over *Acacia ligulata* and *Acacia jamesiana* sparse mid shrubland, over *Halgania cyanea* sparse low shrubs, over *Triodia basedowii* open hummock grassland
Q	*Callitris columellaris* sparse tall shrubland, over *Triodia melvillii* open hummock grassland
R	*Melaleuca xerophila* open tall shrubland, over *Muellerolimon salicorniaceum* sparse low shrubland, over *Eragrostis eriopoda* sparse tussock grassland
S	*Tecticornia* spp., *Frankenia cinerea*, *Maireana villosa* and *Atriplex amnicola* sparse low shrubland
T	*Tecticornia* spp., *Cratystylis subspinescens* and *Scaevola spinescens* sparse low shrubland
U	*Tecticornia* spp., *Maireana amoena* and *Scaevola collaris* sparse low shrubland, over *Eragrostis lanipes* sparse tussock grassland
V	*Tecticornia* spp., *Cratystylis subspinescens*, *Maireana amoena* and *Sclerolaena diacantha* sparse mid shrubland, over *Eragrostis falcata* sparse tussock grassland
W	*Eucalyptus striaticalyx* sparse low woodland, over *Grevillea sarissa* sparse tall shrubland, over *Lawrencia helmsii* sparse low shrubland

Figure 9.28: Vegetation mapping – overview

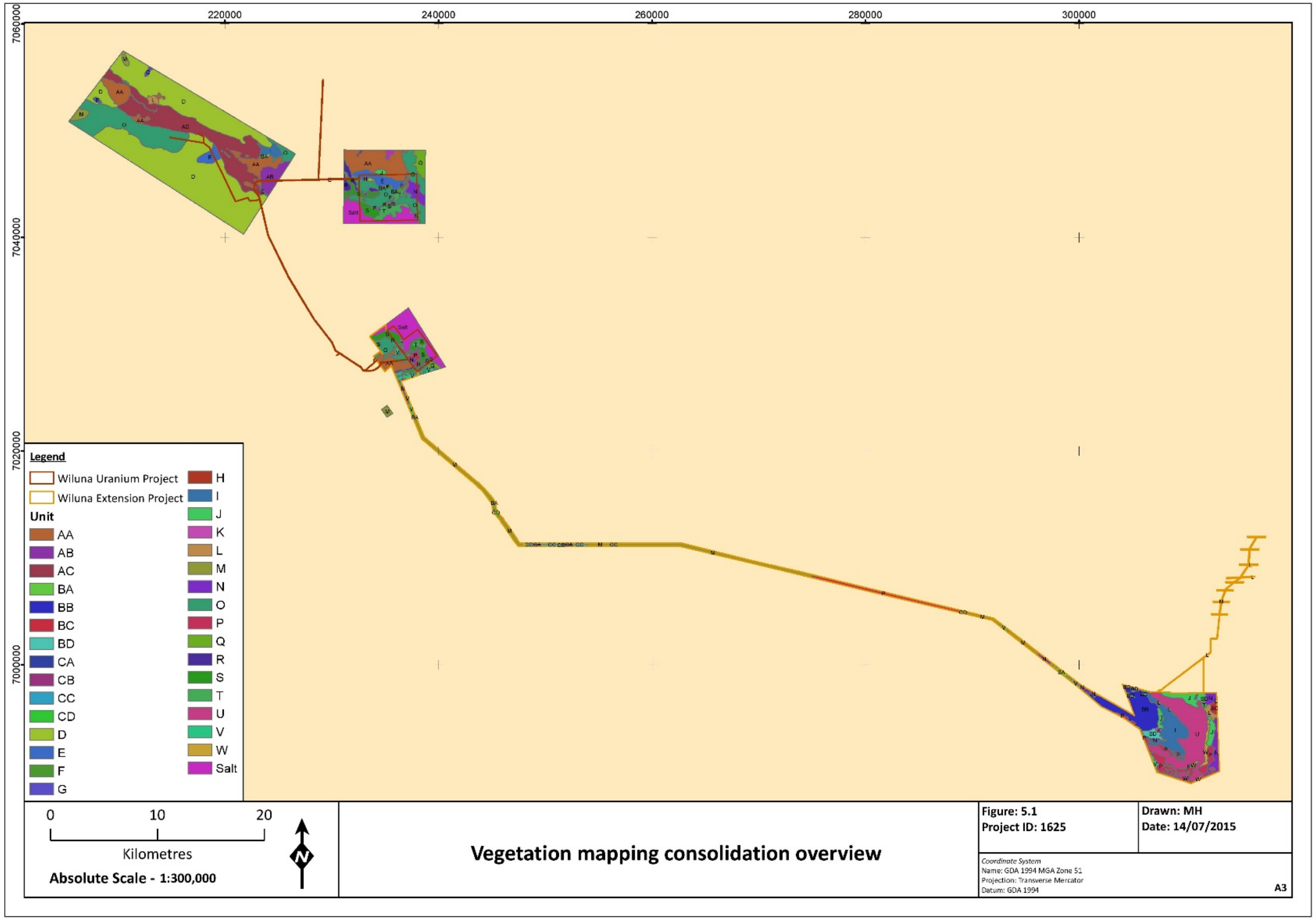


Figure 9.29: Vegetation mapping consolidation – Millipede/Centipede/Lake Way

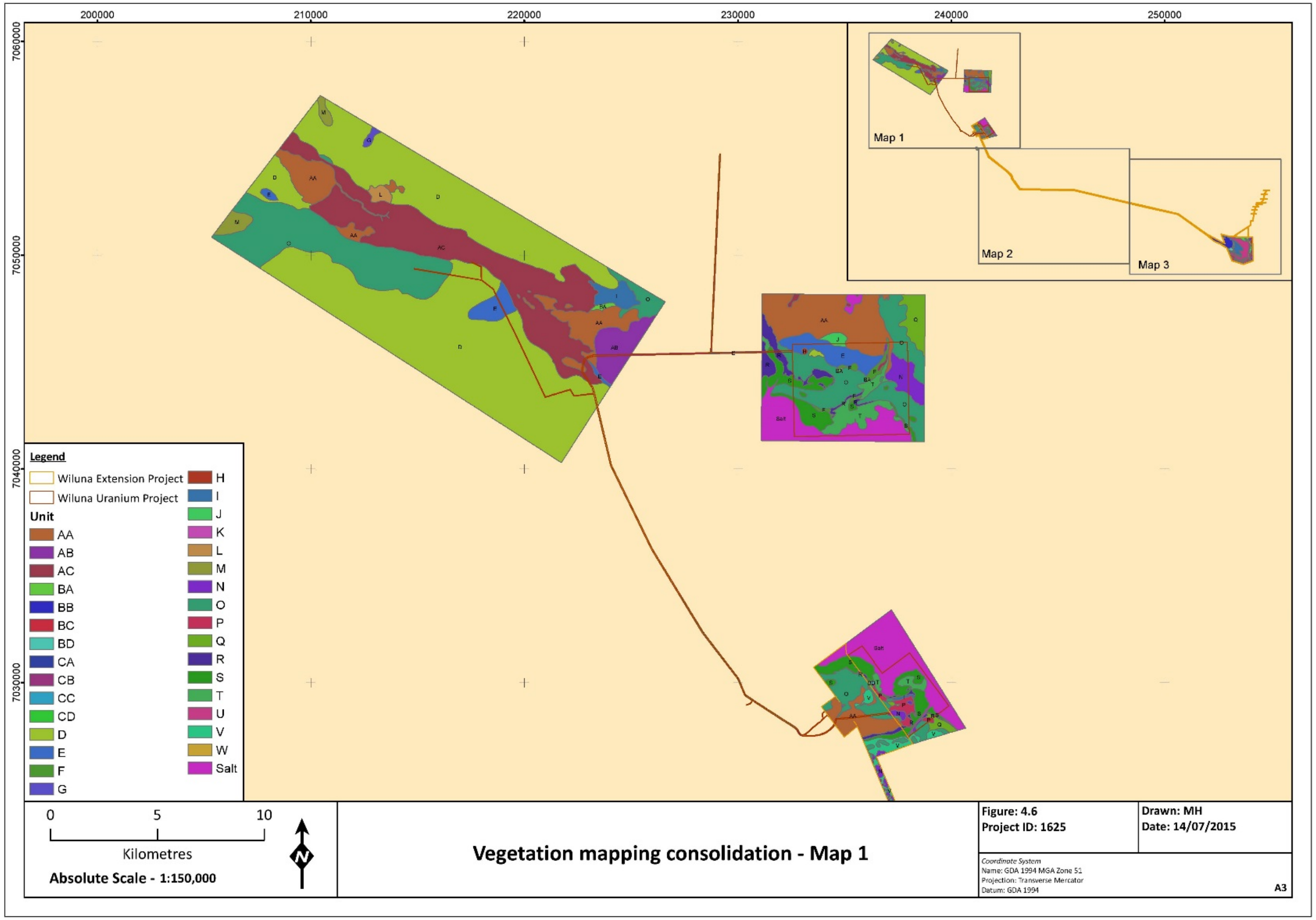


Figure 9.30: Vegetation mapping consolidation – Haul Road

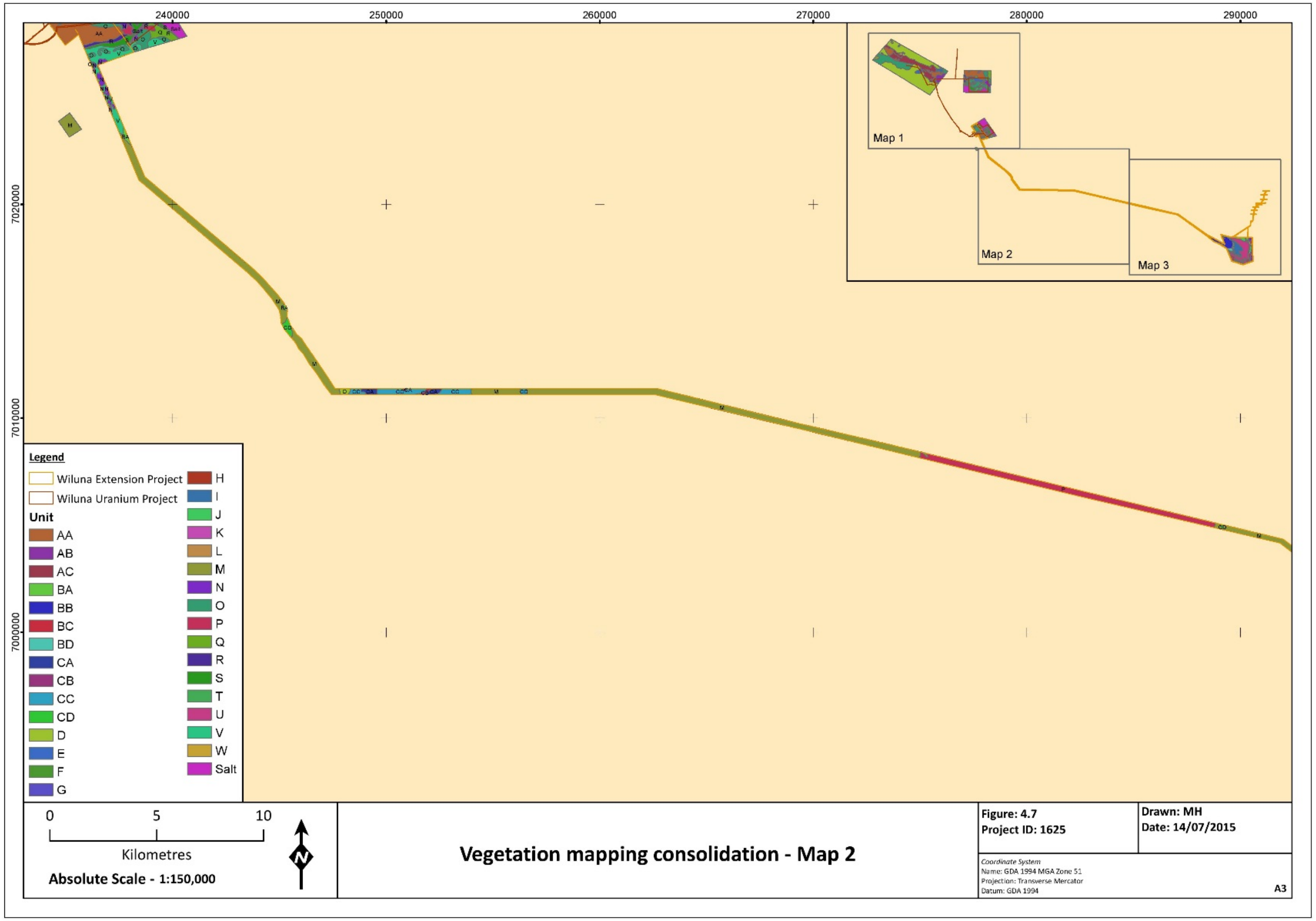


Figure 9.31: Vegetation mapping consolidation – Lake Maitland

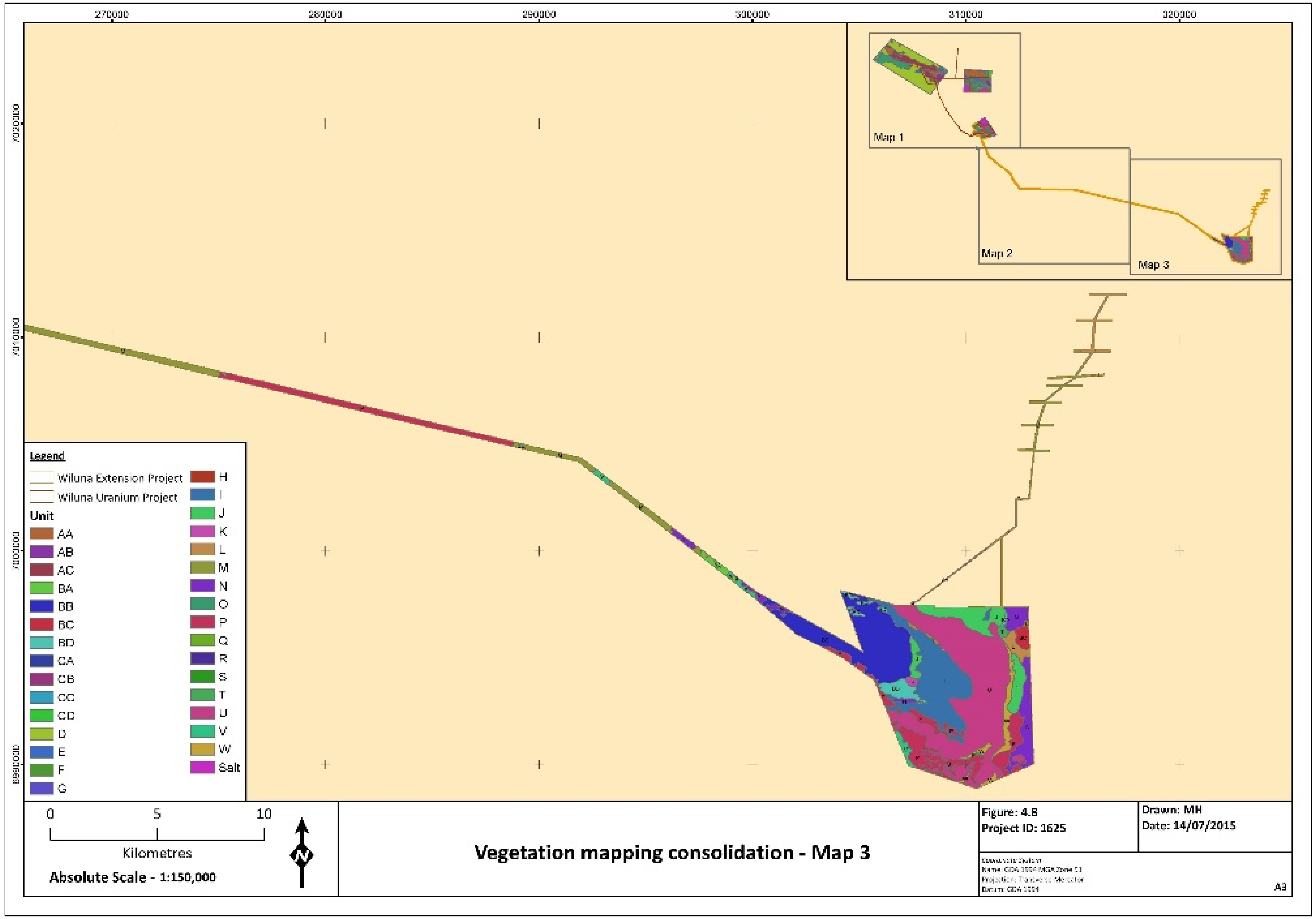


Table 9.29: Vegetation unit direct impacts (ha)

Vegetation Unit	Extension to the Wiluna Uranium Project									Wiluna Uranium Project	Cumulative Project total	Mapped extent
	Extent within development envelope				Extent within disturbance footprint							
	Millipede	Haul Road	Lake Maitland	Lake Maitland Borefield	Millipede	Haul Road	Lake Maitland	Lake Maitland Borefield	Total			
AA	203.9	-	-	-	143.0	-	-	1.0	143.9	48.2	192.1	2,560.0
AB	-	-	-	-	-	-	-	-	-	12.2	12.2	465.0
AC	-	-	-	-	-	-	-	-	-	2.5	2.5	3,009.2
BA	-	8.4	-	-	-	6.7	-	-	6.7	0.1	7.0	92.3
BB	-	23.5	101.2	0.3	-	18.8	9.9	0.3	29.1	-	27.4	1,105.6
BC	-	-	-	-	-	-	-	-	-	-	-	59.7
BD	0.001	-	-	-	0.001	-	-	-	0.001	4.1	4.1	180.3
CA	-	4.7	-	-	-	3.7	-	-	3.7	-	3.7	34.6
CB	-	0.7	-	-	-	0.5	-	-	0.5	-	0.5	6.6
CC	-	17.1	-	-	-	13.7	-	-	13.7	-	13.5	122.2
CD	-	3.1	-	-	-	2.5	-	-	2.5	-	2.5	25.4
D	-	1.7	-	-	-	1.3	-	-	1.3	37.8	39.2	9,226.8
E	0.2	-	-	-	0.1	-	-	-	0.1	14.1	14.2	630.3
F	-	-	8.3	-	-	-	4.0	-	4.0	19.2	23.2	86.9
G	-	-	-	0.02	-	-	-	0.02	0.02	-	0.02	32.6
H	-	-	-	-	-	-	-	-	-	0.7	0.7	6.2
I	-	-	657.2	-	-	-	109.7	-	109.7	14.8	122.0	1,121.0
J	-	-	125.9	1.0	-	-	34.2	-.9	35.2	-	34.9	548.5
K	-	-	-	-	-	-	-	-	-	-	-	19.7
L	-	-	40.3	9.6	-	-	6.3	9.2	15.5	-	15.8	283.4
M	-	165.3	-	10.3	-	132.6	-	9.9	142.4	6-.6	202.0	1,562.7
N	17.5	13.4	5.3	2.3	8.1	10.7	-	2.2	21.0	31.5	53.1	800.5
O	305.7	-	-	-	226.1	-	-	-	226.1	336.5	562.7	3,987.8

Vegetation Unit	Extension to the Wiluna Uranium Project									Wiluna Uranium Project	Cumulative Project total	Mapped extent
	Extent within development envelope				Extent within disturbance footprint							
	Millipede	Haul Road	Lake Maitland	Lake Maitland Borefield	Millipede	Haul Road	Lake Maitland	Lake Maitland Borefield	Total			
P	0.1	52.7	200.0	-	0.1	42.3	31.3	-	73.7	91.2	165.3	1,144.1
Q	-	-	-	-	-	-	-	-	-	6.3	6.3	288.5
R	27.0	-	-	-	21.2	-	-	-	21.2	103.6	124.8	325.1
S	111.0	-	0.01	0.04	92.7	-	-	-	92.7	323.9	416.8	821.2
T	-	-	3.9	-	-	-	0.2	-	0.2	308.9	309.1	431.4
U	-	-	1,527.3	0.1	-	-	545.5	.1	545.6	-	547.6	1,984.1
V	73.5	13.7	-	-	46.6	11.0	-	-	57.6	0.9	59.7	324.0
W	-	-	154.5	-	-	-	35.2	-	35.2	-	35.9	172.9
Salt Pan	-	-	-	-	-	-	-	-	143.9	112.9	112.9	1,813.4
Total	**739.0**	**304.2**	**2,824.0**	**23.6**	**537.9**	**243.9**	**776.4**	**23.6**	**1,581.7**	**1,530.0**	**3,111.7**	**-**

Table 9.30: Vegetation unit indirect impacts (ha)

Vegetation Unit	Groundwater drawdown	Dust deposition	Total mapped extent
AA	1,196.7	-	2,560.0
AB	463.1	-	465.0
AC	2,162.3	-	3,009.2
BA	28.3	12.92	92.3
BB	428.9	36.06	1,105.6
BC	59.4	-	59.7
BD	136.7	-	180.3
CA	0.0	7.13	34.6
CB	0.0	1.04	6.6
CC	0.0	26.14	122.2
CD	0.0	4.77	25.4
D	3,284.5	2.56	9,226.8
E	528.9	-	630.3
F	64.0	-	86.9
G	0.8	-	32.6
H	6.2	-	6.2
I	850.3	-	1,121.0
J	513.6	-	548.5
K	19.7	-	19.7
L	193.4	-	283.4
M	122.7	253.42	1,562.7
N	378.0	20.53	800.5
O	884.7	-	3,987.8
P	518.9	80.79	1,144.1
Q	55.1	-	288.5
R	74.1	-	325.1
S	401.3	-	821.2
T	104.7	-	431.4
U	1,345.0	-	1,984.1
V	201.6	21.17	324.0
W	117.1	-	172.9
Salt Pan	1,321.5		1,813.4

When considered at a local mapping scale, 24 of the 31 locally defined vegetation assemblages would be impacted over less than 20% of the area mapped during baseline studies for the Wiluna Uranium Project including its proposed Extension. Toro is unaware of any other proposals in the Wiluna region likely to affect these vegetation units. Accordingly cumulative impacts on these units may be considered insignificant.

Seven locally mapped vegetation units are predicted to experience disturbance to more than approximately 20% of the known local extent of the vegetation units observed during baseline studies. In only one instance does the proposed disturbance of a local vegetation mapping unit amount to more than 70% of the extent of the unit recorded during baseline studies. Less than 0.25 ha of vegetation unit 'T', a low sparse shrub land mainly encounted at Lake Way, lies within the direct impact footprint of a local mapped extent of 431 ha. Accordingly the incremental impact on this vegetation type resulting form the implementation of the Project is predicted to be insignificant.

9.7.2 Significant Flora

The total estimated plant numbers have been calculated from a variety of sources including the reports listed above and:

- FloraBase, Level 5 searches for all known records in Western Australia; and
- DPaW database searches, conducted for the haul road study area in September 2014 (search reference 32-0514FL, buffer of 50 km).

Government records vary considerably in the amount of detail regarding abundance that is available ranging from accurate counts of general abundance descriptions to no detail at all. Where multiple records at the same location were available, the highest numeric estimate was utilised. Where descriptions of abundance only were available, numbers were inferred according to Table 9.31. Where no estimate of abundance was available, it was assumed only one plant was present. This assumption is likely to be an underestimate in many instances, and hence the final estimates of total abundance of each species are likely to be very conservative.

Table 9.31: Conversion table for abundance descriptions

Cover or description	# plants assumed
No cover or number	1
Infrequent, not common, occasional, rare, scattered, sparse	1
Common, locally common, frequent	30
Abundant	50
<1% cover	1
1–2% cover	5
2–10% cover	10
10–30% cover	20
30–70% cover	30
70–100% cover	40

Details of each significant flora taxon from the Project are described below, and they are mapped (where coordinates are available) on Figure 9.32 (overview) and for each species in Table 9.32. CIA calculations of total plant numbers are presented in Table 9.32.

Table 9.32: Significant flora direct impacts

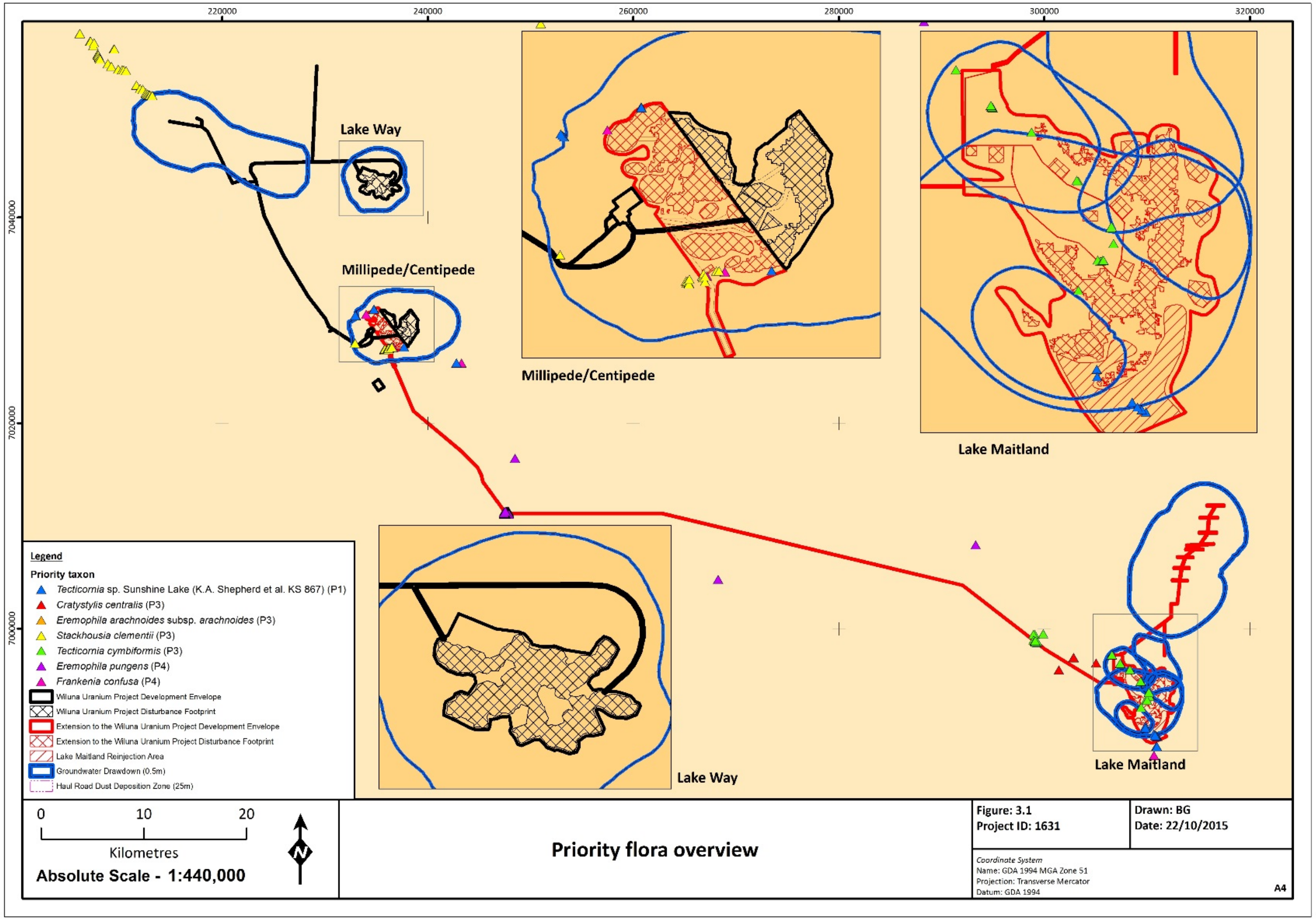
Taxa	Extension to the Wiluna Uranium Project								Wiluna Uranium Project	Cumulative Project	Total Known Individuals
	Extent within development envelope				Extent within disturbance footprint						
	Millipede	Haul Road	Lake Maitland	Total	Millipede	Haul Road	Lake Maitland	Total			
Priority 1											
Eremophila arachnoides subsp. *arachnoides*	-	-	-	-	-	-	-	-	-	-	184
Eremophila congesta	-	-	-	-	-	-	-	-	-	-	10
Tecticornia sp. Lake Way	-	-	-	-	-	-	-	-	-	-	2,004
Tecticornia sp. Sunshine Lake	15	-	66	81	-	-	-	-	-	-	233
Priority 3											
Cratystylis centralis	-	-	-	-	-	-	-	-	-	-	1,817
Homalocalyx echinulatus	-	-	-	-	-	-	-	-	-	-	1
Maireana ?prosthecochaeta	-	-	-	-	-	-	-	-	-	-	1
Mirbelia stipitata	-	-	-	-	-	-	-	-	-	-	1
Stackhousia clementii	81	-	-	81	-	-	-	-	-	-	1,531
Tecticornia cymbiformis	-	50	320	370	-	50	10	60	-	60	5,578
Priority 4											
Eremophila pungens	-	608	-	608	-	608	-	608	-	608	2,302
Frankenia confusa	36	-	-	36	-	-	-	-	-	-	685
New taxa											
Tecticornia aff. *halocnemoides* s.l. 'large ovate seed aggregate'	41	-	60	101	10	-	20	30	-	30	118
Tecticornia aff. *halocnemoides* s.l. 'tuberculate seed'	-	-	35	35	-	-	-	-	-	-	55
Tecticornia sp. aff. Burnerbinmah (inflated fruit)	1	-	-	1	1	-	-	1	-	1	1
Tecticornia sp. aff. *globulifera* (small)	21	-	131	152	1	-	20	21	-	21	443
Tecticornia sp. aff. *laevigata* (non-rotated fruitlets)	20	-	22	42	-	-	-	-	-	-	108
Tecticornia sp. aff. *pruinosa* (inflated bracts)	-	-	-	-	-	-	-	-	-	-	5
Tecticornia sp. aff. *undulata* (broad articles)	-	-	223	223	-	-	2	2	-	2	467
Potential new taxa											

Taxa	Extension to the Wiluna Uranium Project								Wiluna Uranium Project	Cumulative Project	Total Known Individuals
	Extent within development envelope				Extent within disturbance footprint						
	Millipede	Haul Road	Lake Maitland	Total	Millipede	Haul Road	Lake Maitland	Total			
?*Tecticornia* sp. aff. *globulifera* (small)	-	-	20	20	-	-	-	-	-	-	25
Tecticornia aff. *halocnemoides* (unusual epidermis)	-	-	30	30	-	-	-	-	-	-	30
Tecticornia sp. aff *laevigata*	-	-	-	-	-	-	-	-	1	1	9
Tecticornia sp. aff *pruinosa*	-	-	-	-	-	-	-	-	12	12	33
Tecticornia sp. aff. *undulata*	-	-	-	-	-	-	-	-	5	5	24
Tecticornia sp. *halocnemoides* beaked seed aggregate	-	-	-	-	-	-	-	-	4	4	16
Tecticornia sp. nov.	-	-	-	-	-	-	-	-	-	-	1
Atypical variants											
Frankenia ?interioris	-	-	-	-	-	-	-	-	-	-	1
Frankenia sp. aff. *fecunda* (glabrous leaf variant)	21	-	-	21	-	-	-	-	-	-	149
Frankenia sp. cf. *glomerata*	-	-	-	-	-	-	-	-	-	-	2
Rhagodia drummondii	-	-	-	-	-	-	-	-	-	-	1
Scaevola spinescens	-	-	-	-	-	-	-	-	-	-	1
Surreya ?diandra	-	-	-	-	-	-	-	-	-	-	1
Range Extensions											
?*Gompholobium simplicifolium*	-	-	-	-	-	-	-	-	-	-	1
Acacia aneura var. cf *major*	-	-	-	-	-	-	-	-	-	-	3
Acacia brumalis	-	-	3	3	-	-	-	-	-	-	3
Acacia heteroneura var. *jutsonii*	-	-	-	-	-	-	-	-	-	-	5
Acacia maxwellii	-	-	1	1	-	-	-	-	-	-	1
Acacia scleroclada	-	-	-	-	-	-	-	-	-	-	1
Brachyscome iberidifolia	-	-	-	-	-	-	-	-	-	-	1
Cratystylis subspinescens	-	-	-	-	-	-	-	-	-	-	1
Cynanchum floribundum	-	-	-	-	-	-	-	-	-	-	2
Dicrastylis doranii	-	-	-	-	-	-	-	-	-	-	1
Disphyma crassifolium subsp. *clavellatum*	-	-	-	-	-	-	-	-	1	1	1
Dysphania plantaginella	-	-	-	-	-	-	-	-	-	-	2

Taxa	Extension to the Wiluna Uranium Project								Wiluna Uranium Project	Cumulative Project	Total Known Individuals
	Extent within development envelope				Extent within disturbance footprint						
	Millipede	Haul Road	Lake Maitland	Total	Millipede	Haul Road	Lake Maitland	Total			
Dysphania truncata	-	-	-	-	-	-	-	-	-	-	1
Euphorbia biconvexa	-	-	-	-	-	-	-	-	-	-	1
Frankenia interioris	-	-	-	-	-	-	-	-	1	1	1
Gnephosis angianthoides	-	-	-	-	-	-	-	-	1	1	1
Gunniopsis rodwayi	-	-	-	-	-	-	-	-	-	-	1
Gunniopsis septifraga	-	-	-	-	-	-	-	-	1	1	1
Isoetopsis graminifolia	-	-	-	-	-	-	-	-	-	-	1
Maireana amoena	-	-	-	-	-	-	-	-	-	-	1
Maireana appressa	-	-	-	-	-	-	-	-	-	-	1
Maireana lobiflora	-	-	-	-	-	-	-	-	-	-	2
Maireana luehmannii	2	-	-	2	1	-	-	1	-	1	4
Mollugo cerviana	-	-	-	-	-	-	-	-	-	-	1,000
Murchisonia volubilis	-	-	-	-	-	-	-	-	1	1	1
Nicotiana rotundifolia	-	-	-	-	-	-	-	-	1	1	1
Paspalidium gracile	-	1	-	1	-	1	-	1	-	1	1,007
Polygala isingii	-	-	-	-	-	-	-	-	-	-	1
Pterocaulon sphacelatum	-	-	-	-	-	-	-	-	-	-	1
Ptilotus murrayi	-	-	-	-	-	-	-	-	1	1	1
Scaevola tomentosa	1	-	-	1	1	-	-	1	4	5	14
Sclerolaena clelandii	-	-	1	1	-	-	-	-	-	-	1
Senna manicula	-	-	-	-	-	-	-	-	-	-	1
Sida kingii	-	-	-	-	-	-	-	-	-	-	5
Sporobolus caroli	1	-	-	1	-	-	-	-	-	-	1
Tecticornia halocnemoides subsp. *catenulata*	-	-	-	-	-	-	-	-	7	7	11
Tecticornia moniliformis	-	-	-	-	-	-	-	-	8	8	12
Tecticornia pterygosperma subsp. *pterygosperma*	-	-	10	10	-	-	-	-	-	-	10
Tecticornia tenuis	50	-	-	50	20	-	-	20	-	20	50
Thyridolepis xerophila	-	-	-	-	-	-	-	-	-	-	3

Taxa	Extension to the Wiluna Uranium Project								Wiluna Uranium Project	Cumulativ e Project	Total Known Individuals
	Extent within development envelope				Extent within disturbance footprint						
	Millipede	Haul Road	Lake Maitland	Total	Millipede	Haul Road	Lake Maitland	Total			
Trachymene ceratocarpa	-	-	-	-	-	-	-	-	1	1	1
Triodia plurinervata	-	-	-	-	-	-	-	-	-	-	1
Other *Tecticornia* taxa											
Tecticornia calyptrata	18	-	10	28	-	-	-	-	-	-	31
Tecticornia disarticulata	20	-	-	20	-	-	-	-	-	-	23
Tecticornia doleiformis	2	-	-	2	-	-	-	-	1	1	5
Tecticornia indica	30	-	-	30	-	-	-	-	-	-	85
Tecticornia indica subsp. *bidens*	57	-	22	79	20	-	6	26	11	37	209
Tecticornia indica subsp. *leiostachya*	73	-	-	73	10	-	-	10	-	10	119
Tecticornia laevigata	1	30	201	232	1	3-	55	86	11	97	2,416
Tecticornia peltata	10	-	106	116	-	-	-	-	4	4	325
Tecticornia pergranulata	5	-	-	5	-	-	-	-	-	-	5
Tecticornia pruinosa	1	-	21	22	-	-	-	-	-	-	26
Tecticornia pterygosperma subsp. *denticulata*	1	-	-	1	-	-	-	-	-	-	34
Tecticornia sp. Burnerbinmah	101	-	70	171	50	-	-	50	6	56	195
Tecticornia sp. Dennys Crossing	127	-	-	127	82	-	-	82	-	82	580
Tecticornia undulata	-	-	-	-	-	-	-	-	-	-	22
Introduced flora											
Acetosa vesicaria	5	-	-	5	5	-	-	5	50	55	90
Bidens bipinnata	-	-	-	-	-	-	-	-	-	-	1,301
Brassica tournefortii	-	-	-	-	-	-	-	-	-	-	1
Carpobrotus sp.	-	-	-	-	-	-	-	-	1	1	3
Centaurea melitensis	-	-	-	-	-	-	-	-	-	-	2
Citrullus ?lanatus	-	-	-	-	-	-	-	-	-	-	2
Lysimachia arvensis	-	-	-	-	-	-	-	-	-	-	1
Sonchus oleraceus	-	-	-	-	-	-	-	-	-	-	1
Tribulus terrestris	-	-	-	-	-	-	-	-	-	-	2

Figure 9.32: Significant flora records – overview



Priority Flora

In flora and vegetation assessments for the Wiluna Uranium Project and The Extension to the Wiluna Uranium Project, 12 Priority flora taxa have been recorded (Table 9.32). These are:

- *Eremophila arachnoides* subsp. *arachnoides* (Priority 1);
- *Eremophila congesta* (Priority 1);
- *Tecticornia* sp. Lake Way (P. Armstrong 05/961) (Priority 1);
- *Tecticornia* sp. Sunshine Lake (K.A. Shepherd et al. KS 867) (Priority 1);
- *Cratystylis centralis* (Priority 3);
- *Homalocalyx echinulatus* (Priority 3);
- *Maireana ?prosthecochaeta* (Priority 3);
- *Mirbelia stipitata* (Priority 3);
- *Stackhousia clementii* (Priority 3);
- *Tecticornia cymbiformis* (Priority 3);
- *Eremophila pungens* (Priority 4); and
- *Frankenia confusa* (Priority 4).

Eremophila arachnoides subsp. *arachnoides* has been recorded at the Millipede, Centipede and Lake Way deposits by Niche, 2011a (Appendix 10.12). During these surveys, specific locations of plants were not collected, rather the number of plants were recorded along transects and a density per hectare of habitat that it occurs on calculated. As locations are not available for this species, they have not been mapped.

The numbers estimated are:

- Millipede: recorded high numbers at 22.67 plants per hectare, on calcrete vegetation unit Low Woodland B of *Acacia* species, equivalent to vegetation unit AA. Niche (2011a - Appendix 10.12), estimated 5,440 plants occurring in the area on an estimated habitat of 240 ha. Using the total amount of vegetation unit AA to be impacted at Millipede and the process plant (325.4 ha), and the estimated number of plants per hectare provided by Niche (22.67) it is estimated that 7,377 plants will be impacted at Millipede.
- Centipede: low habitat availability at Centipede and an estimated 130 plants are to be impacted.
- Lake Way: recorded in high numbers at 22.8 plants per hectare, recorded on calcrete vegetation units Open Low Woodland A of *Eucalyptus gypsophila* and Low Woodland B of *Acacia* species, equivalent to vegetation units AA, E and J. Niche (2011a - Appendix 10.12) estimated 18,331 plants occurring at Lake Way and the surrounding area on an estimated habitat of 804 ha. Using the total of vegetation units AA, E and J to be impacted at Lake Way (73.7 ha), and the estimated number of plants per hectare provided by Niche (22.8) it is estimated that 1,680 plants will be impacted in the Lake Way mining area.
- Regional survey: approximately 100 km north of Wiluna estimated a very high density of plants at 30.4 plants per hectare, with as much as 600 ha of habitat and therefore an estimated number of 18,240 plants occurring.

Of the four Priority 1 plant species recorded in the course of baseline studies for the Wiluna Uranium Project and the proposed Extension, none lie within areas proposed for disturbance. An estimated 55 individuals of the Priority 1 species *Tecticornia* sp Sunshine Lake (KA Shepherd *et al.* KS 867) occur within the areas circumscribed by the 0.5 m groundwater drawdowns arising from mining at Millipede, Centipede and Lake Maitland (assuming that the proposed low permeability perimeter barriers are wholly ineffective). This represents 23.6% of the known population of the species.

Of the six Priority 3 plant species recorded in the course of baseline studies, only one (*Tecticornia cymbiformis*) would be directly impacted. An estimated 60 plants, or about 1.1% of the known population of this species may be cleared. An estimated 760 individuals of *T cymbiformis* lie within the predicted 0.5m groundwater drawdown contour resulting from mining proposed at Lake Maitland. This represents 13.6% of the known population of *Tecticornia cymbiformis*. The groundwater dependency of this species has not been established.

One Priority 4 species, *Eremophila pungens*, would be impacted by implementation of the Wiluna Uranium Project and its proposed Extension: up to 608 plants lie within the current footprint defined for the mine haul road from Lake Maitland. This represents approximately 26.4% of the known population of this species. Further refinement of the Project design may allow avoidance of a proportion of the plants within the road alignment.

New Flora Taxa

Seven new taxa have been identified from specimens collected by Ecologia from Lake Way and Lake Maitland (Shepherd 2015 - Appendix 10.33). The seven new taxa are:

- *Tecticornia* aff. *halocnemoides s.l.* 'large ovate seed aggregate' has been recorded at 13 locations (representing 57 individuals), nine of which are within the direct impact area (four at the Millipede deposit at Lake Way and five at Lake Maitland), one in the indirect impact area at Millipede and three to the south of the Lake Maitland deposit.
- *Tecticornia* aff. *halocnemoides s.l.* 'tuberculate seed' has been recorded at four locations (representing 32 individuals), all at Lake Maitland, two locations are within the direct impact area, one in the indirect impact area and one location to the south of the Lake Maitland deposit.
- *Tecticornia* sp. aff. *Burnerbinmah* (inflated fruit) has been recorded from a single location, representing a single individual within the direct impact area of the Millipede deposit at Lake Way.
- *Tecticornia* sp. aff. *globulifera* (small) has been recorded from 43 locations (representing 86 individuals). Twenty of these records are located within the direct impact areas (4 at Millipede deposit at Lake Way, and 16 at the Lake Maitland deposit). Three additional locations are within the indirect impact areas (1 at Millipede, 2 at Lake Maitland). The remaining 20 records (representing 41 individuals) are from Lake Way, west of the Millipede deposit (8 records representing 19 individuals) and south of Lake Maitland deposit (12 records representing 22 individuals).
- *Tecticornia* sp. aff. *laevigata* (non-rotated fruitlets) has been recorded at 11 locations (representing 27 individuals), seven of which are within direct impact areas (two in the Millipede deposit at Lake Way, and five at Lake Maitland). One additional record is from the indirect impact area at Lake Maitland and three records (representing five individuals) are located outside impact areas (two at Lake Way and one at Lake Maitland).
- *Tecticornia* sp. aff. *pruinosa* (inflated bracts) has been recorded from a single location (representing one individual) from approximately 70 m outside the direct impact, but within the indirect impact area to the north of the Lake Maitland deposit.
- *Tecticornia* sp. aff. *undulata* (broad articles) has been recorded from 51 locations (representing 148 individuals), 26 of which are within the direct impact area of Lake Maitland. An additional eight locations have been recorded from indirect impact areas (three at Millipede deposit and two at centipede deposit at Lake Way, and three at Lake Maitland). The remaining 17 records (representing 82 individuals) are from Lake Way outside the Millipede and Centipede mining areas (seven records representing 42 individuals), south of the Lake Maitland deposit (eight records representing 47 individuals) and from a small salt lake located approximately 10 km north-west of Lake Maitland and 400 m north of the haul road alignment (two locations representing 25 individuals).

Potentially New Flora Taxa

An additional seven potentially new taxa were also recorded (Table 9.32):

- ?*Tecticornia* sp. aff. *globulifera* (small) (Shepherd 2015 - Appendix 10.33);
- *Tecticornia* aff. *halocnemoides* (unusual epidermis) (Shepherd 2015 - Appendix 10.33);
- *Tecticornia* sp. aff *laevigata* (Actis 2012 – Appendix 10.61);
- *Tecticornia* sp. aff *pruinosa* (Actis 2012 – Appendix 10.61);
- *Tecticornia* sp. aff. *undulata* (Actis 2012 – Appendix 10.61);
- *Tecticornia* sp. *halocnemoides* beaked seed aggregate (Actis 2012 – Appendix 10.61); and
- *Tecticornia* sp. nov. (Actis 2012 – Appendix 10.61).

Atypical Variants

Six atypical variants have also been recorded (Table 9.32):

- *Frankenia* ?*interioris* (Niche 2011a – Appendix 10.12);
- *Frankenia* sp. aff. *fecunda* (glabrous leaf variant) (Ecologia 2015a – Appendix 10.36);
- *Frankenia* sp. cf. *glomerata* (Niche 2011a – Appendix 10.12);
- *Rhagodia drummondii* (Niche 2011a – Appendix 10.12);
- *Scaevola spinescens* (Niche 2011a – Appendix 10.12); and
- *Surreya* ?*diandra* (Ecologia 2015a – Appendix 10.36).

Range Extensions

Thirty-nine range extensions have also been recorded (Table 9.32).

Other Tecticornia Taxa

In addition to those listed above, 14 *Tecticornia* taxa have also been recorded (Table 9.32).

Introduced Flora

Nine introduced flora species have been recorded (Table 9.32).

Direct Impacts

The direct impacts of the Wiluna Uranium Project and the Extension to the Wiluna Uranium Project to significant flora are outlined in Table 9.32. Direct impacts are defined as the area approved for clearing under the Wiluna Uranium Project and the proposed disturbance footprint for the Extension to the Wiluna Uranium Project (although impacts for the development envelope for the Extension to Wiluna Uranium Project are also included). An overview of significant flora records is provided in Figure 9.32.

Indirect Impacts

The indirect impacts of the Wiluna Uranium Project and the Extension to the Wiluna Uranium Project to significant flora are outlined in Table 9.33. They include the impacts of groundwater drawdown and dust deposition.

Groundwater Drawdown

The indirect impacts due to groundwater abstraction are defined here as the area within the 0.5 m drawdown contours for the Lake Way deposit, Centipede/Millipede deposit, Lake Maitland deposit, West Creek Borefield, and Lake Maitland Borefield components of the Wiluna Uranium Project and the Extension to the Wiluna Uranium Project. The number of individual plants directly impacted is excluded from the calculation of indirect impacts where those individuals indirectly impacted fall within direct impact zone (Table 9.33).

Dust Deposition

The indirect impacts due to dust deposition are defined here as within 25 m either side of the Millipede to Lake Maitland Haul Road. The number of individual plants directly impacted is excluded from the calculation of indirect impacts where those individuals indirectly impacted fall within direct impact zones (Table 9.33).

Table 9.33: Significant flora indirect impacts

Taxa	Groundwater drawdown	Dust deposition	Total known individuals
Priority 1			
Eremophila arachnoides subsp. *arachnoides*	-	-	184
Eremophila congesta	-	-	10
Tecticornia sp. Lake Way (P. Armstrong -5/961)	-	-	2,004
Tecticornia sp. Sunshine Lake (K.A. Shepherd et al. KS 867)	55	-	233
Priority 3			
Homalocalyx echinulatus	-	-	1
Maireana ?prosthecochaeta	-	-	1
Mirbelia stipitata	-	-	1
Stackhousia clementii	36	-	1,531
Tecticornia cymbiformis	760	-	5,578
Priority 4			
Eremophila pungens	-	250	2,302
Frankenia confuse	10	-	685
New taxa			
Tecticornia aff. *halocnemoides* s.l. 'large ovate seed aggregate'	61	-	118
Tecticornia aff. *halocnemoides* s.l. 'tuberculate seed'	45	-	55
Tecticornia sp. aff. Burnerbinmah (inflated fruit)	-	-	1
Tecticornia sp. aff. *globulifera* (small)	131	-	443
Tecticornia sp. aff. *laevigata* (non-rotated fruitlets)	47	-	108
Tecticornia sp. aff. *pruinosa* (inflated bracts)	5	-	5
Tecticornia sp. aff. *undulata* (broad articles)	198	-	467
Potential new taxa			
?*Tecticornia* sp. aff. *globulifera* (small)	5	-	25
Tecticornia aff. *halocnemoides* (unusual epidermis)	-	-	30
Tecticornia sp. aff *laevigata*	2	-	9
Tecticornia sp. aff *pruinosa*	10	-	33
Tecticornia sp. aff. *undulata*	8	-	24
Tecticornia sp. *halocnemoides* beaked seed aggregate	7	-	16
Tecticornia sp. nov.	-	-	1
Atypical variants			
Frankenia ?interioris	-	-	1
Frankenia sp. aff. *fecunda* (glabrous leaf variant)	20	1	149
Frankenia sp. cf. *glomerata*	-	-	2
Rhagodia drummondii	-	-	1
Scaevola spinescens	-	-	1
Surreya ?diandra	-	-	1
Range Extensions			
?*Gompholobium simplicifolium* (as ?*Otion simplicifolium*)	-	-	1

Acacia aneura var. cf *major*	-	-	3
Acacia brumalis	2	-	3
Acacia heteroneura var. *jutsonii*	-	-	5
Acacia maxwellii	-	-	1
Acacia scleroclada	-	-	1
Brachyscome iberidifolia	-	-	1
Cratystylis subspinescens	-	-	1
Cynanchum floribundum	-	-	2
Dicrastylis doranii	-	-	1
Disphyma crassifolium subsp. *clavellatum*	-	-	1
Dysphania plantaginella	-	-	2
Dysphania truncata	-	-	1
Euphorbia biconvexa	-	-	1
Frankenia interioris	-	-	1
Gnephosis angianthoides	-	-	1
Gunniopsis rodwayi	-	-	1
Gunniopsis septifraga	-	-	1
Isoetopsis graminifolia	-	-	1
Maireana amoena	-	-	1
Maireana appressa	-	-	1
Maireana lobiflora	-	-	2
Maireana luehmannii	-	-	4
Mollugo cerviana	-	-	1,000
Murchisonia volubilis	-	-	1
Nicotiana rotundifolia	-	-	1
Paspalidium gracile	-	-	1,007
Polygala isingii	-	-	1
Pterocaulon sphacelatum	-	-	1
Ptilotus murrayi	-	-	1
Scaevola tomentosa	-	-	14
Sclerolaena clelandii	-	-	1
Senna manicula	-	-	1
Sida kingie	-	-	5
Sporobolus caroli	-	-	1
Tecticornia halocnemoides subsp. *catenulata*	3	-	11
Tecticornia moniliformis	3	-	12
Tecticornia pterygosperma subsp. *pterygosperma*	-	-	10
Tecticornia tenuis	30	-	50
Thyridolepis xerophila	-	-	3
Trachymene ceratocarpa	-	-	1
Triodia plurinervata	-	-	1
Other *Tecticornia* taxa			
Tecticornia calyptrata	19	-	31
Tecticornia disarticulata	22	-	23

Tecticornia doleiformis	2	-	5
Tecticornia indica	30	-	85
Tecticornia indica subsp. *bidens*	84	-	209
Tecticornia indica subsp. *leiostachya*	68	-	119
Tecticornia laevigata	194	-	2,416
Tecticornia peltata	28	-	325
Tecticornia pergranulata	5	-	5
Tecticornia pruinosa	22	-	26
Tecticornia pterygosperma subsp. *denticulata*	33	-	34
Tecticornia sp. Burnerbinmah (D. Edinger et al. 1-1)	127	-	195
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	293	-	580
Tecticornia undulata	-	-	22
Introduced flora			
Acetosa vesicaria	-	-	90
Bidens bipinnata	-	-	1,301
Brassica tournefortii	-	-	1
Carpobrotus sp.	-	-	3
Centaurea melitensis	-	-	2
Citrullus ?lanatus	-	-	2
Lysimachia arvensis	-	-	1
Sonchus oleraceus	-	-	1
Tribulus terrestris	1	-	2

9.8 Commitments

Toro’s engineering studies to complete design of the Proposal would take into account areas where priority flora and vegetation is known to exist and infrastructure would be located to minimise any disturbance.

The Environmental Management Plan (Appendix 4) includes monitoring, reporting and other actions to mitigate impacts on flora and vegetation from implementation of the Proposal, including on groundwater dependent vegetation and *Tecticornia* species.

Toro would undertake progressive rehabilitation of disturbed areas to ensure they meet agreed post-mining completion criteria.

9.9 Outcome

Toro does not anticipate that the implementation of the Proposal would affect the conservation status of any plant species or particular ecosystem. Toro is committed to avoiding impacts to vegetation to the maximum extent possible and this has been reflected in the design of the Proposal to date. In the Definitive Feasibility Study planned prior to the implementation of the Proposal, further minimisation of impacts would be sought.

The Environmental Management Plan (Appendix 4), as well as a *Tecticornia* Survey and Research Plan would ensure that impacts are managed appropriately and rehabilitation would be successful.

Toro has concluded that the Proposal can be constructed, operated and closed in a way which maintains the abundance, diversity, geographic distribution and productivity of native plant species in the area.

10 TERRESTRIAL FAUNA

10.1 Objective

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

10.2 Relevant Legislation and Policy

All native fauna in Western Australia are protected under the *Wildlife Conservation Act 1950*. This includes particularly fauna species that are rare, threatened with extinction, or have high conservation value. The Wildlife Conservation (Special Protected Fauna) Notice classifies rare and endangered fauna using four conservation codes or schedules:

- Schedule 1: Fauna which are rare or likely to become extinct and are declared to be fauna in need of special protection;
- Schedule 2: Fauna which are presumed to be extinct and are declared to be fauna in need of special protection;
- Schedule 3: Birds which are subject to international agreements and conventions relating to the protection of migratory birds and birds in danger of extinction, which are declared to be fauna in need of special protection; and
- Schedule 4: Fauna that are in need of special protection, for reasons other than those reasons mentioned in Schedules 1, 2 or 3.

In addition to the above schedules, DPaW maintains a supplementary list of Priority Fauna. Priority Fauna are species that have been identified as requiring further survey and evaluation of their conservation status before deciding whether to list them as Scheduled Fauna. DPaW applies the same five Priority codes for fauna as it applies to flora and vegetation (see Section 9.2).

The EPA Position Statement No. 3 outlines the use of terrestrial biological surveys as an element of biodiversity protection in Western Australia (EPA, 2002). Proponents are expected to undertake field surveys that meet the standards, requirements and protocols as determined and published by the EPA. Based on the guidance provided in Position Statement No. 3, Toro has undertaken Level 2 biological surveys for assessment of the impacts of the Proposal. This has included desktop studies, a reconnaissance survey and comprehensive fauna surveys to assess conservation values in a local and regional context. Further detail on the requirements for fauna surveys is provided in EPA Guidance Statement No. 56 (EPA, 2004b) and Technical Guide on Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment (EPA and DEC, 2010).

The EPA also provides guidance on the rehabilitation of terrestrial ecosystems (EPA, 2006).

Fauna species of national conservation significance are listed under the EPBC Act and are classified in the same way as listed threatened plant and ecological communities (see Section 9.2).

Migratory wader species are also protected under the EPBC Act. The national list of migratory species consists of those species listed under the following international conventions:

- Japan-Australia Migratory Bird Agreement (JAMBA);
- China-Australia Migratory Bird Agreement (CAMBA); and
- Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention).

Under the EPBC Act, a proposal which is likely to have a significant impact on threatened species, populations or ecological communities, or migratory species must be referred to the federal DoE for a decision by the Minister for Environment as to whether the action is a ‘controlled action’. A significant impact is determined through application of Significant Impact Criteria (DEWHA, 2009).

10.3 Proponent Studies and Investigations

10.3.1 Millipede and Ore Haul Road

As Millipede is a geological extension of the Centipede ore body, information obtained during Toro's previous assessment of fauna values at Centipede was used to augment a desk top review of information about terrestrial fauna at Millipede (Ecologia, 2014b – Appendix 10.3).

The haul road from Lake Maitland to the proposed processing plant location adjacent to the Millipede tenements has also been studied. This commenced with a search of the various databases to identify the conservation significant fauna recorded within a 100 km radius of the haul road. The results of eight previous fauna surveys conducted within 100 km of the haul road were also reviewed (Ecologia, 2015b – Appendix 10.4). The results of this background research are presented in Table 10.1, Table 10.2 and Table 10.3.

Table 10.1: Fauna databases searched to determine the potential vertebrate fauna assemblage

Database	Custodian	Search Details
NatureMap (which incorporates the results of the DPaW Threatened Fauna Database)	DPaW	40 km radius around the centre of the study area. Coordinate: 51 J: 270185 E, 7010593 N Date accessed: 07/07/14
Species Profile and Threats (SPRAT) Database (DoE Protected Matters Report)	Department of Environment (DoE)	100 km radius around the centre of the study area. Coordinate: 51 J: 270185 E, 7010593 N Date accessed: 07/07/14
Birdata	BirdLife Australia	Records within one square decimal degree (100 sq km). Coordinate: 51 J: 270185 E, 7010593 N Date accessed: 07/07/14

Table 10.2: Previous biological survey reports within 100 km of the study area

Survey Report and Author	Distance to Study Area (km)	Comments	Date(s) undertaken
Ecologia internal database	63	Single-phase Level 2 survey	N/A
Lake Way Baseline Terrestrial Fauna Survey (Outback Ecology, 2008a – Appendix 10.21)	0-30	Single-phase Level 2 survey	May and December 2007
Lake Way Baseline Fauna Studies (Outback Ecology, 2002) Unpublished report for Wiluna Gold Mine.	0-30	Level 1 survey	2-7 October 2002
Lake Maitland Infrastructure Areas Baseline Terrestrial Fauna Surveys (Outback Ecology, 2011b – Appendix 10.18)	70	Level 1 survey	14-21 October 2009

Survey Report and Author	Distance to Study Area (km)	Comments	Date(s) undertaken
Terrestrial Fauna Habitat Assessment - Borefield, Accommodation Camp and Access Route (Outback Ecology, 2011b – Appendix 10.18)	70	Level 1 survey	2-6 August 2010
Wiluna Uranium Terrestrial Fauna Habitat Assessment (Outback Ecology, 2011c – Appendix 10.52)	4	Single-phase Level 2 survey	17-20 May 2011
Lake Maitland Baseline Terrestrial Fauna Survey (Outback Ecology, 2009a – Appendix 10.16)	70	Two-phase Level 2 survey	Reconnaissance survey – 22-25 January 2007 Systematic fauna surveys – 7-16 May 2007

Table 10.3: Number of species recorded during previous surveys and database searches - Millipede

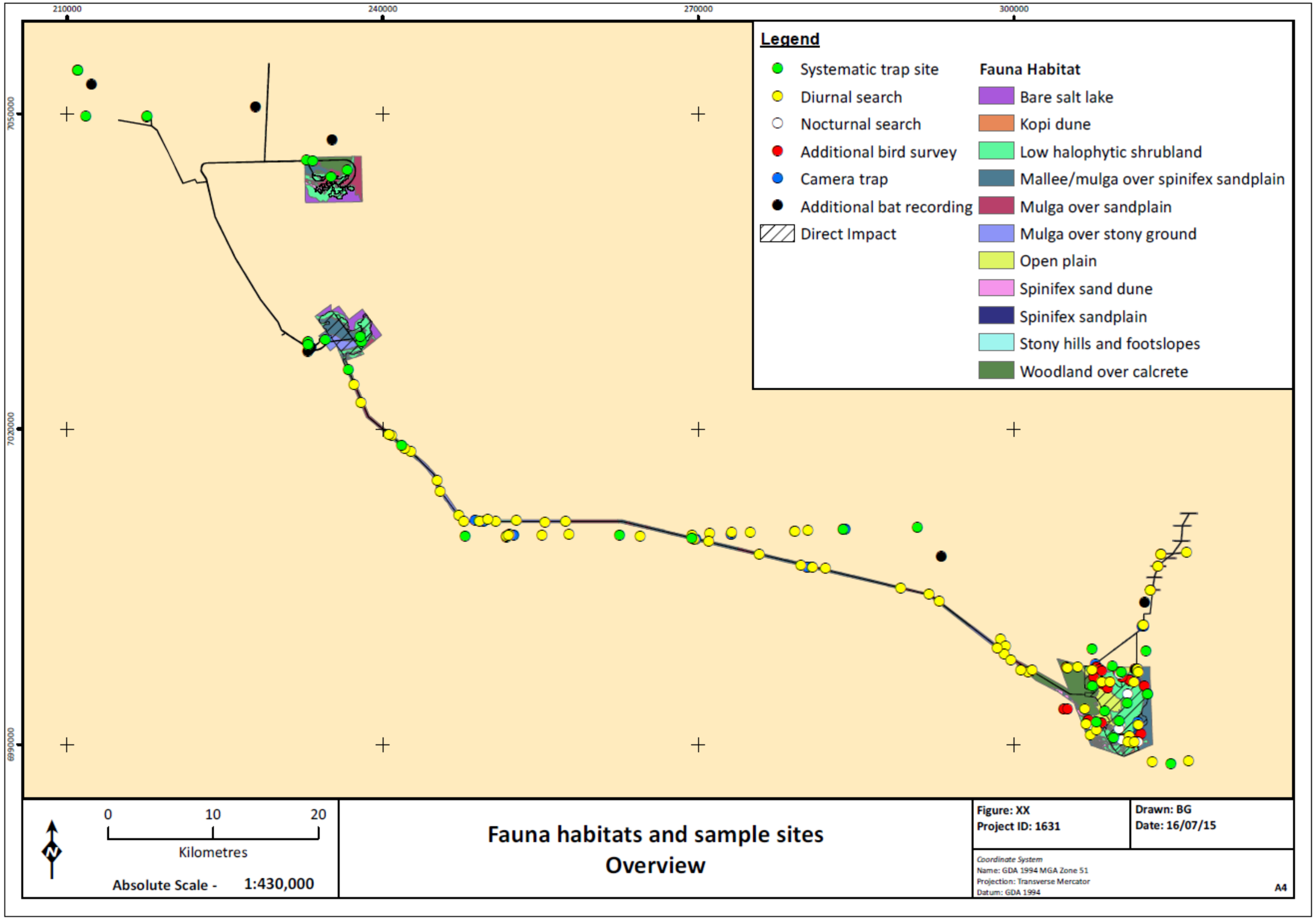
Source/Report	Mammals (Native/ Introduced)	Birds (Native/ Introduced)	Reptiles	Amphibians
Ecologia internal database	15/5	74/0	34	4
Lake Way Baseline Terrestrial Fauna Survey (Outback Ecology, 2008a – Appendix 10.21)	13/7	53/0	30	-
Lake Way Baseline Fauna Studies (Outback Ecology, 2002) Unpublished report for Wiluna Gold Mine.	0/1	21/0	9	1
Lake Maitland Infrastructure Areas Baseline Terrestrial Fauna Surveys (Outback Ecology, 2011b – Appendix 10.18)	5/5	30/0	9	-
Terrestrial Fauna Habitat Assessment - Borefield, Accommodation Camp and Access Route (Outback Ecology, 2011b – Appendix 10.18)	7/4	4/0	1	-
Wiluna Uranium Terrestrial Fauna Habitat Assessment (Outback Ecology, 2011c – Appendix 10.52)	12/8	45/0	34	-
Lake Maitland Baseline Terrestrial Fauna Survey (Outback Ecology, 2009a – Appendix 10.16)	17/7	60/0	38	-
NatureMap	23/1	77/0	55	6
SPRAT Database	3/7	6/1	1	-
Birdata	n/a	121/0	n/a	n/a
Individual Species Total	**34/11**	**133/1**	**77**	**8**

To supplement this existing information, a Level 1 reconnaissance survey was conducted in winter (6–10 June 2014) and a Level 2 vertebrate fauna assessment was conducted in spring (6–17 October 2014) (Ecologia, 2015b – Appendix 10.4) for the haul road alignment between the proposed location of the processing plant and Lake Maitland. The survey timing was determined in compliance with EPA guidelines (EPA, 2004a; EPA and DEC, 2010).

Habitat types previously described by Outback Ecology at Lake Way (Outback Ecology, 2008a – Appendix 10.21) and Lake Maitland (Outback Ecology, 2009a – Appendix 10.16) were reviewed for relevance to the haul road study area, and interpreted for survey site selection. Locations of access tracks, land systems and the abundance of habitat types were also taken into consideration. Survey sites were selected to provide a good geographic spread and to be representative of the habitat types in the study area. Therefore, dominant habitat types were sampled by a larger number of trapping sites than less represented habitat types.

Systematic trapping sites were installed in the Carnegie (one site), Bullimore (four sites), Ararak (one site) and Rainbow (one site) land systems. In addition to systematic surveys, opportunistic searches were undertaken, targeting habitats or land systems less accessible or less represented within the study area (Ecologia, 2015b – Appendix 10.4). The locations of the investigation sites are presented in Figure 10.1. It shows the locations of all surveys of fauna habitats, including those for mining at Centipede and Lake Way, as well as at Millipede and Lake Maitland.

Figure 10.1: Locations of fauna habitat surveys for the Wiluna Uranium Project, Including its Extension



10.3.2 Lake Maitland

Between 2009 and 2010, two vertebrate fauna assessments were undertaken at Lake Maitland:

- Lake Maitland Baseline Terrestrial Fauna Survey (Outback Ecology, 2009a – Appendix 10.16); and
- Lake Maitland Infrastructure Areas Baseline Terrestrial Fauna Surveys (Outback Ecology, 2011b – Appendix 10.18).

These assessments comprised one initial field reconnaissance survey, two Level 1 field and habitat assessment surveys and one Level 2 field survey and habitat assessment (Table 10.4).

In 2015, Engenium undertook a further Level 2 terrestrial fauna and targeted reptile search (Appendix 10.8) across the Project area to meet current EPA requirements (Table 10.4).

Table 10.4: Summary of survey types and timing

Survey Report and Author	Distance to Study Area (km)	Comments	Dates undertaken
Lake Maitland Baseline Terrestrial Fauna Survey (Outback Ecology, 2009a – Appendix 10.16))	N/A	Desktop assessment	N/A
	0	Field reconnaissance survey	22–25 January 2007
	0	Level 2 field survey and habitat assessment	7–16 May 2007
		Level 2 field survey and habitat assessment	7–13 December 2007
Lake Maitland Infrastructure Areas Baseline Terrestrial Fauna Surveys (Outback Ecology, 2011a – Appendix 10.18)	N/A	Desktop assessment	N/A
	0	Level 1 field survey and habitat assessment	14–21 October 2009; 2-6 August 2010
Lake Maitland Level 2 Vertebrate Fauna and Targeted Reptile Survey (Engenium, 2015 – Appendix 10.8).	0	Level 2 Assessment	17–27 March 2015

Table 10.5: Number of species recorded during previous surveys and database searches – Lake Maitland

Source/Report	Mammals (Native/ Introduced)	Birds (Native/ Introduced)	Reptiles	Amphibians
Engenium internal database	17/3	73/0	35	4
Lake Maitland to Millipede Haul Road Vertebrate Fauna and Fauna Habitat Assessment (Ecologia Environment, 2015b – Appendix 10.4)	14/5	56/0	35	1
Lake Maitland Infrastructure Areas Baseline Terrestrial Fauna Survey (Outback Ecology, 2011b – Appendix 10.18)	7/5	30/0	10	0
Lake Way Baseline Terrestrial Fauna Survey (Outback Ecology, 2008a – Appendix 10.21)	13/7	53/0	30	1
Wiluna Uranium Terrestrial Fauna Habitat Assessment (Outback Ecology, 2011c – Appendix 10.52)	12/8	45/0	34	-
Lake Maitland Baseline Terrestrial Fauna Survey (Outback Ecology, 2009a – Appendix 10.16)	17/7	60/0	38	-
NatureMap	23/1	77/0	55	6
SPRAT Database	3/7	6/1	1	-
Birdata	n/a	121/0	n/a	n/a
Individual Species Total	**34/11**	**133/1**	**77**	**8**

10.4 Existing Environment – Millipede and Haul Road

No threatened fauna species listed under the EPBC Act or Priority Fauna Species listed under the DPaW Priority Species List were observed during field surveys conducted for the Proposal. No threatened or priority fauna have been recorded during previous surveys conducted by others in the same area.

During Toro's baseline fauna surveys, two fauna species listed under the EPBC Act as Migratory were recorded: the Rainbow Bee-eater (*Merops ornatus*) and Sharp-tailed Sandpiper (*Calidris acuminatus*).

10.4.1 Land Systems - Millipede

The land systems in the Millipede study area have been discussed in Section 9.4 and are shown in Figure 9.2. In summary, Millipede is located on two land systems, Carnegie and Cunyu. Table 10.6 shows that the dominant land system is Carnegie. Both systems are well represented outside the area studied. The study area occupied less than 0.1% of both the Carnegie and Cunyu systems (Ecologia 2014b – Appendix 10.3).

Table 10.6: Land systems – Millipede

Land System	Description	Total area in Murchison IBRA region (ha)	Area within the study area (ha)	Proportion of study area (%)	Proportion of total land system (%)
Carnegie	Salt lakes with extensively fringing saline plains, dunes and sandy banks, supporting low halophytic shrublands and scattered tall *Acacia* shrublands; lake beds are highly saline; gypsiferous and mainly unvegetated.	1,185,900	894.4	95.5	0.07
Cunyu	Calcrete platforms and intervening alluvial floors and minor areas of alluvial plains, including channels with *Acacia* shrublands and minor halophytic shrublands.	290,390	42.5	4.5	0.01

10.4.2 Fauna Habitat – Millipede

Outback Ecology (2009a – Appendix 10.16) previously identified six broad habitat types at the adjacent Centipede deposit. The desktop assessment at Millipede identified five broad habitat types. The five fauna habitats identified during the most recent assessment were:

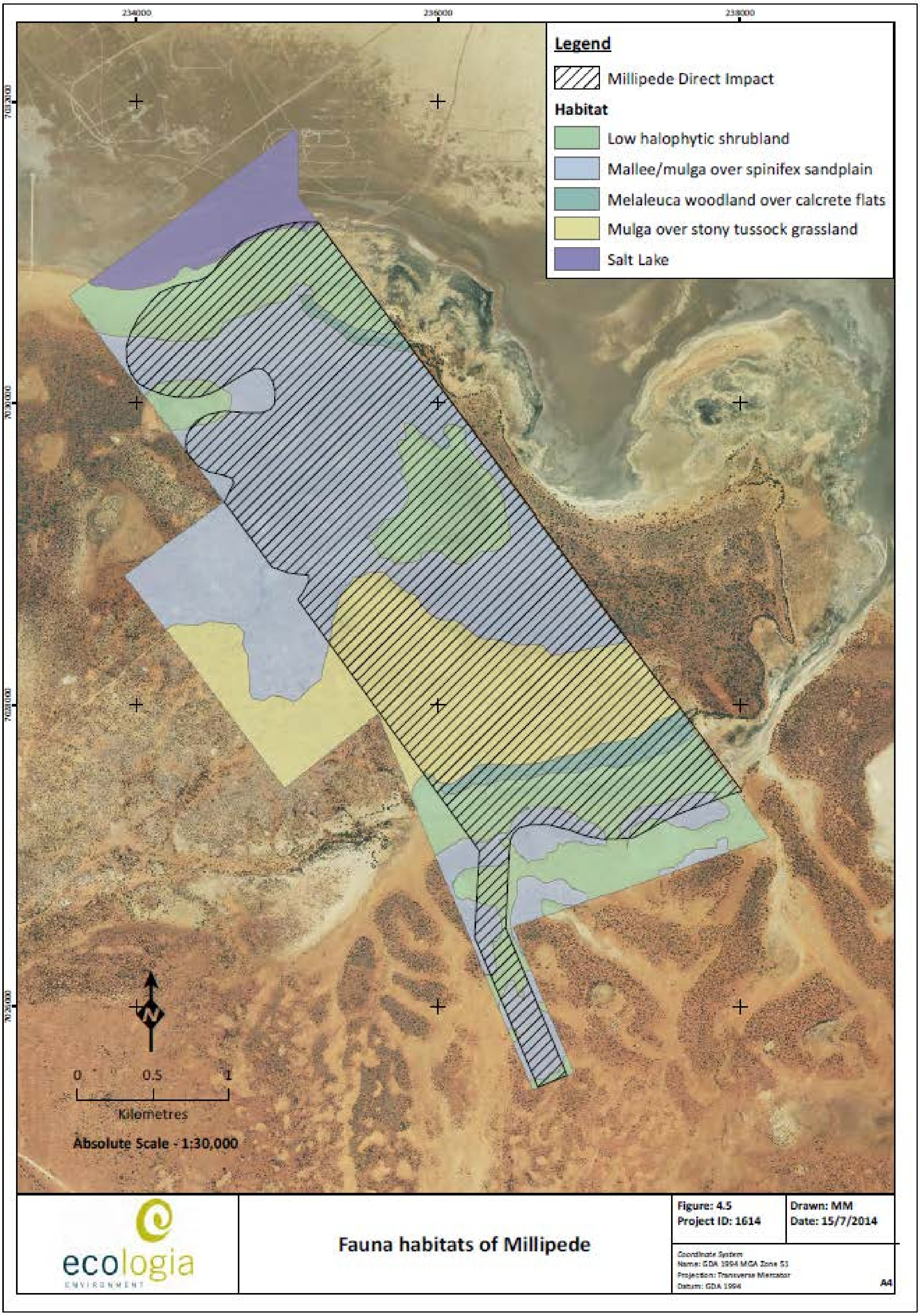
- Mulga over stony tussock grassland;
- Mallee/mulga over spinifex sandplain;
- *Melaleuca* woodland over calcrete flats;
- Salt lake; and
- Low halophytic shrubland.

A map of the habitat types is shown in Figure 10.2.

Mallee/mulga over spinifex sandplain comprises approximately 44.4% (523.8 ha) of the study area. The vegetation is characterised by open mature mulga (*Acacia caesaneura, A. pruinocarpa*) woodland with occasional mallees (*Eucalyptus kingsmillii* and *E. lucasii*) over sparse shrubland of *Eremophila forrestii* and *Acacia* spp., with open *Triodia basedowii* hummock grassland. The soil substrate consists of a firm orange-brown clay-sand, suitable for burrowing mammals and reptiles. Leaf-litter is abundant under large mallee and *Acacia* trees and shrubs, while wood-litter is moderate. Similar habitat is present outside the study area and is likely to be well-represented in the surrounding region (Outback Ecology, 2011c – Appendix 10.52).

The low halophytic shrubland habitat comprises 32.2% (380.3 ha) of the study area. The vegetation is characterised by chenopods and shrubs including *Maireana*, *Atriplex*, *Salsola*, *Solanum*, *Senna*, *Sclerolaena* and *Frankenia* with sparse *Aristida contorta* tussock grassland. The soil substrate consists of a loose orange-brown sandy-clay, with many quartz pebbles, suitable for burrowing reptiles. Leaf-litter and wood-litter is absent. This habitat is well-represented within the region, particularly in association with salt lakes (Outback Ecology, 2011c – Appendix 10.52).

Figure 10.2: Fauna habitats across the Millipede Tenements



Mulga over stony tussock grassland comprises 16.1% (189.5 ha) of the study area. The vegetation is characterised by sparse *Acacia pruinocarpa* or *Acacia caesaneura* woodland over open *Eremophila forrestii* and *Acacia aneura*-complex shrubs, with open *Aristida contorta*, *Eragrostis eriapoda*, *Monachather paradoxus* and *Eriachne* sp. tussock grassland. The soil substrate consists of a firm brownish sandy-clay or clay-loam. Leaf-litter is found only under trees and shrubs, and wood-litter is generally sparse to moderate. Similar habitat is widespread in the region (Outback Ecology, 2011c – Appendix 10.52).

Salt lake habitat occurs in the northern section of the study area, where it extends onto Lake Way itself, and comprises 4.8% (56.5 ha) of the study area. This habitat type refers to the bare, flat areas of salt lakes and is devoid of vegetation, and consequently leaf litter. The habitat type occurs across much of Lake Way itself.

The *Melaleuca* woodland over calcrete flats habitat comprises 2.5% (29.3 ha) of the study area. The vegetation is characterised by open *Melaleuca xerophila* woodland over *Acacia* spp., *Sclerolaena* and *Eremophila* shrubland with sparse *Triodia basedowii* hummock grassland and *Eragrostis eriapoda* tussock grassland. The soil substrate consists of a loose orange-brown sandy-clay, with scattered pebbles. Leaf-litter occurs under trees and shrubs, while wood-litter is moderate. This habitat type is relatively limited within the region and is largely restricted to the lake fringes (Outback Ecology, 2011c – Appendix 10.52).

10.4.3 Fauna Assemblages – Millipede

The results of the literature review (Ecologia 2014b – Appendix 10.3) indicated a total of 34 native mammal species, 142 bird species, 77 reptile species and eight amphibian species have the potential to occur within the study area. A breakdown of the families for each group is provided in Table 10.7.

Table 10.7: Summary of vertebrate fauna groups potentially occurring within the study area – Millipede

Family	No. of native species	No. of conservation significant species	Family	No. of native species	No. of conservation significant species
Native mammals					
Tachyglossidae	1	0	Macropodidae	4	1
Dasyuridae	10	2	Emballonuridae	2	0
Thylacomyidae	1	1	Vespertilionidae	7	0
Peramelidae	1	1	Molossidae	2	0
Notoryctidae	1	1	Muridae	3	0
Potoroidae	1	1	Canidae	1	0
Birds					
Casuariidae	1	0	Cuculidae	4	0
Megapodiidae	1	1	Strigidae	1	0
Phasianidae	1	0	Tytonidae	1	0
Anatidae	6	0	Halcyonidae	2	0
Podicipedidae	2	0	Meropidae	1	1
Columbidae	3	0	Climacteridae	1	0
Podargidae	1	0	Ptilonorhynchidae	1	0
Eurostopodidae	1	0	Maluridae	4	0

Family	No. of native species	No. of conservation significant species	Family	No. of native species	No. of conservation significant species
Aegothelidae	1	0	Acanthizidae	9	0
Apodidae	1	1	Pardalotidae	2	0
Anhingidae	1	0	Meliphagidae	15	0
Phalacrocoracidae	1	0	Pomatostomidae	2	0
Pelecanidae	1	0	Psophodidae	3	0
Ardeidae	3	1	Neosittidae	1	0
Threskiornithidae	1	0	Campephagidae	3	0
Accipitridae	10	0	Pachycephalidae	3	0
Falconidae	5	2	Artamidae	7	0
Rallidae	2	0	Rhipiduridae	1	0
Otididae	1	1	Corvidae	3	0
Burhinidae	1	1	Monarchidae	1	0
Recurvirostridae	3	0	Petroicidae	3	0
Charadriidae	6	1	Megaluridae	3	0
Scolopacidae	1	1	Hirundinidae	4	0
Turnicidae	1	0	Nectariniidae	1	0
Cacatuidae	3	0	Estrildidae	1	0
Psittacidae	6	1	Motacillidae	1	0
Reptiles					
Cheluidae	1	0	Pygopodidae	6	0
Agamidae	11	0	Scincidae	26	1
Diplodactylidae	11	0	Varanidae	7	0
Carphodactylidae	4	0	Typhlopidae	2	0
Gekkonidae	3	0	Elapidae	6	0
Amphibians					
Hylidae	3	0	Limnodynastidae	5	0

10.4.4 Conservation Significant Fauna – Millipede

The desktop studies have concluded that there is the potential for 19 vertebrate species of conservation significance to occur within the study area (Ecologia 2014b – Appendix 10.3). A list of these species and their likelihood of occurring within the study area is presented in Table 10.8, together with the habitat in which these species are likely to occur.

Of all the potential conservation significant fauna that may occur, birds are the most likely. The salt lake environment provides suitable habitat for migratory birds and there is the potential for them to occur periodically within the study area.

Previous studies across the Centipede deposit highlighted the potential for the same mammals to occur at Centipede (Outback Ecology, 2011c – Appendix 10.52). In the Level 2 surveys, however, none of these species were recorded as occurring within the range of the Project.

Table 10.8: Conservation significant fauna occurring or potentially occurring - Millipede

Species	Conservation Significance			Habitat	Previous Records	Likelihood of Occurrence
	EPBC Act	WC Act	DPaW			
Brush-tailed Mulgara			P4	Sand plains and gibber plains with moderately dense spinifex with 'runways' between clumps.	Mulgara recorded from the Lake Maitland area by Outback Ecology (2009a – Appendix 10.16) presumed to represent this taxon, and numerous records within the vicinity of the survey area (DPaW, 2014). Recorded recently on a fauna survey of the nearby Millipede to Lake Maitland haul road study area	MEDIUM Numerous recent records from the region, however none were recorded from trapping sites located within the current study area during the recent Level 2 fauna survey of the Millipede to Lake Maitland Haul Road.
Long-tailed Dunnart *Sminthopsis longicaudata*			P4	Rocky, hilly areas vegetated with spinifex; occasionally open areas with a stony, rocky mantle.	Two recent records approximately 40 km WNW of the study area (DPaW, 2014).	LOW No suitable habitat within the study area, or in close proximity to the study area.
Northern Marsupial Mole *Notoryctes caurinus*	EN	S1	EN	Longitudinal sand dunes, interdunal flats and possibly sandy soils along river flats.	DoE states that the species, or suitable habitat for the species, is likely to occur within the region. No records within 100 km of the study area.	LOW No records within 100 km of the study area. Study area does not contain longitudinal sand dunes or lies within interdunal flats.
Greater Bilby *Macrotis lagotis*	VU	S1	VU	Variety of habitats on soft soil including spinifex hummock grassland, *Acacia* shrubland, open woodland and cracking clays.	Recorded near Wiluna in 1984 (DPaW, 2014). Translocated population present in the region at Lorna Glen Station	LOW No recent records in the vicinity of the survey area and habitat of limited suitability

Species	Conservation Significance			Habitat	Previous Records	Likelihood of Occurrence
	EPBC Act	WC Act	DPaW			
Golden Bandicoot (Barrow Island) *Isoodon auratus barrowensis*	VU	S1	VU	Rocky sandstone spinifex and vine thickets.	Translocated population occurs in the vicinity at Lorna Glen Station.	LOW Not known to occur within the region, with the exception of a translocated population at Lorna Glen Station which is largely restricted to a fenced enclosure at that location.
Burrowing Bettong *Bettongia lesueur lesueur*	VU	S1	VU	Hummock grassland and scrub.	DoE states that the species, or suitable habitat for the species, is likely to occur within the region.	LOW No recent records in the area and currently considered extinct on mainland Australia aside from fenced translocated populations (van Dyck and Strahan, 2008).
Black-flanked Rock-wallaby *Petrogale lateralis lateralis*	VU	S1	VU	Scattered locations amongst rocky outcrops.	One record of questionable veracity c. 70 km to the south of the study area in 2009 (DPaW, 2014).	LOW Only a single record within 100 km of the survey area, and aerial photographs indicate no suitable habitat located within the study area.
Malleefowl *Leipoa ocellata*	VU	S1	VU	Dry inland scrub, mallee.	A number of records from the region, including records c. 40 km WNW and c. 40km S of the study area (DPaW, 2014).	LOW A number of recent records from the region. However, habitat within the study area lacking the dense vegetation of optimal habitat.
Princess Parrot *Polytelis alexandrae*	VU		P4	Sandy deserts; lightly wooded country, including desert oak, open mallee-spinifex and open marble gum woodland.	DoE states that the species, or suitable habitat for the species, may occur within the region. One old record (1964) from c. 50km south of the study area (DPaW, 2014).	LOW No recent records from the vicinity of the study area, and habitat within the study area appears to be of limited suitability for the species.

Species	Conservation Significance			Habitat	Previous Records	Likelihood of Occurrence
	EPBC Act	WC Act	DPaW			
Fork-tailed Swift *Apus pacificus*	M	S3		Nomadic, almost entirely aerial lifestyle over a variety of habitats; associated with storm fronts.	DoE states that the species, or suitable habitat for the species, is likely to occur within the region.	MEDIUM Although there are no records within the vicinity of the study area, this species is highly nomadic, and is likely occasionally pass over the study area in association with summer storm fronts.
Eastern Great Egret *Ardea modesta*	M	S3		Wide range of wetland habitats, including floodwaters, rivers, shallows of wetlands, intertidal mudflats.	DoE states that the species, or suitable habitat for the species, is likely to occur within the region.	LOW No nearby records and little suitable habitat within the study area. Small chance to occur on salt lakes when inundated.
Oriental Plover *Charadrius veredus*	M	S3		Open plains, including samphire; bare rolling country; bare claypans; open ground near inland swamps.	DoE states that the species, or suitable habitat for the species, may occur within the region.	LOW Suitable habitat exists within the study area; however there are no records in the vicinity of the study area and generally an uncommon species within the region. May occasionally occur on the salt lakes.
Sharp-tailed Sandpiper *Calidris acuminata*	M	S3		Coasts and well-watered parts of the interior. Prefer grassy areas of non- tidal fresh or brackish wetlands, coastal marshes and tidal flats.	One record from a previous survey in the region (Outback Ecology, 2011c – Appendix 10.52).	RECORDED Recent record in the vicinity of the study area, and salt lakes within study area would provide suitable habitat when holding water. This species, and other wader species, are likely to use the salt lake habitat on occasion.

Species	Conservation Significance			Habitat	Previous Records	Likelihood of Occurrence
	EPBC Act	WC Act	DPaW			
Rainbow Bee-eater *Merops ornatus*	M	S3		Open country, most vegetation types, dunes, banks; prefer lightly wooded, preferably sandy, country near water.	Recorded on a number of previous surveys in the region and several records from the region (DPaW, 2014).	RECORDED Several recent records from the vicinity of the study area and suitable habitat occurs within the study area.
Grey Falcon *Falco hypoleucos*		S1	VU	Lightly wooded coastal and riverine plains.	One recent record from c. 60 km north of the study area (Ecologia internal database).	HIGH Recent record to the north of the study area, with suitable habitat present in the study area. This species is likely to be at least an occasional visitor to the study area, but unlikely to nest due to a lack of suitable nesting structures.
Peregrine Falcon *Falco peregrinus*		S4	Other	Widespread; coastal cliffs, riverine gorges and wooded watercourses.	Two records within 60 km of the survey area to the south, and recorded widely across the region (DPaW, 2014).	HIGH Two records relatively near the study area and suitable habitat present within the study area. This species is likely to be at least an occasional visitor to the study area, but unlikely to nest due to a lack of suitable nesting structures.
Australian Bustard *Ardeotis australis*			P4	Open grasslands, chenopod flats and low heathland.	Recorded on a number of previous surveys in the region including the recent survey of the Millipede to Lake Maitland haul road study area. Several records from within 100 km of the study area on NatureMap (DPaW, 2014).	HIGH Several recent records from surrounding areas and suitable habitat present within study area.

Species	Conservation Significance			Habitat	Previous Records	Likelihood of Occurrence
	EPBC Act	WC Act	DPaW			
Bush Stone-curlew *Burhinus grallarius*			P4	Lightly wooded country next to daytime shelter of thickets or long grass.	Recorded previously from the Lake Maitland area (Outback Ecology, 2009a – Appendix 10.16) and in the vicinity of the Millipede to Lake Maitland haul road study area, and two records c. 50 km to the south on NatureMap (DPaW, 2014).	HIGH Several recent records from surrounding areas and suitable habitat present within study area.
Great Desert Skink *Liopholis kintorei*	VU	S1	VU	Desert mosaic landscapes with vegetation of different ages.	DoE states that the species, or suitable habitat for the species, may occur within the region. One old record (1964) approximately 50 km south-west of the study area (DPaW, 2014).	LOW No recent records from the vicinity of the study area and habitat within the study area of limited suitability for the species.

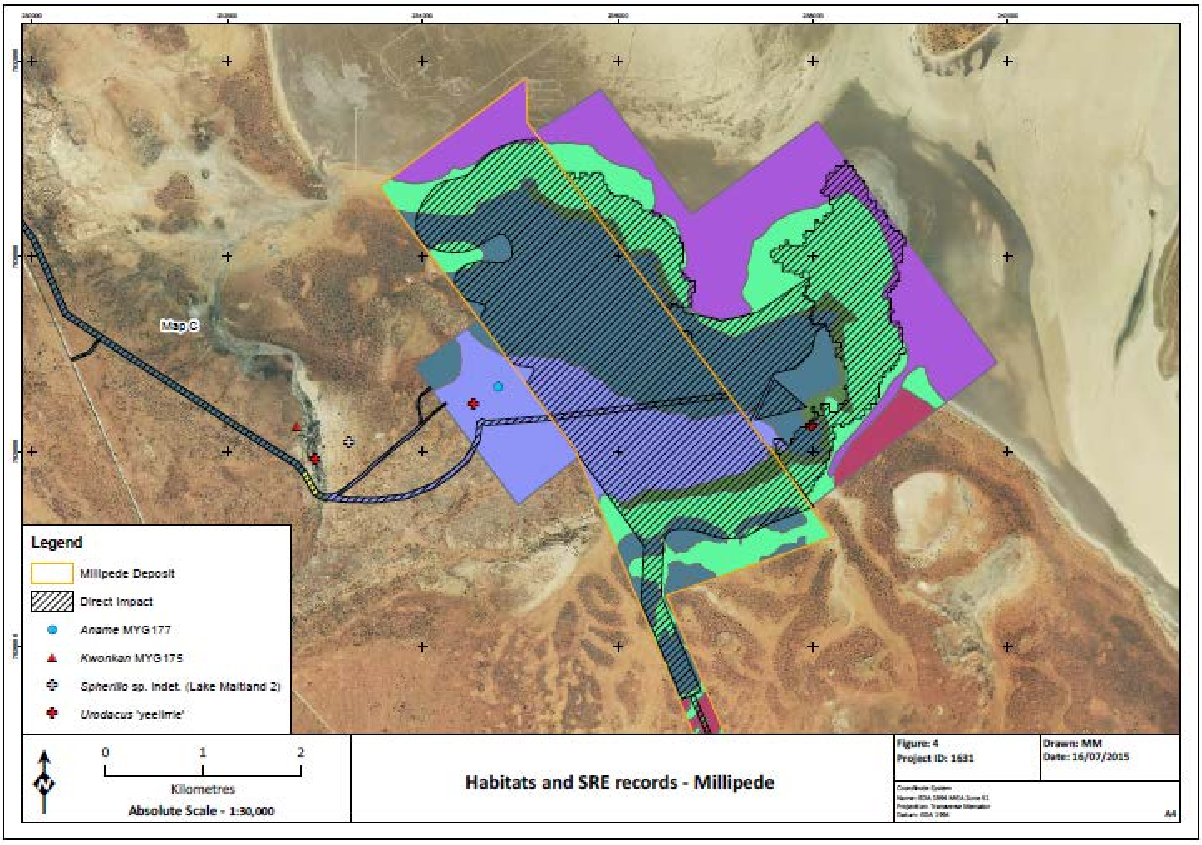
10.4.5 Short-range Endemic Fauna – Millipede

The literature review indicated a total of 103 taxa from SRE groups have been recorded within the study area, although the current paucity of taxonomic information and issues with identification (e.g. female and juvenile mygalomorphs) mean that this number is inexact. Of these, 51 are classified as potential SREs according to the Western Australian Museum Guidelines.

Previous SRE surveys across the Centipede and Lake Way tenements identified five SRE species as occurring. However with the exception of *Aname MYG177* and *Urodacus 'yeelirrie'* none of these are considered any longer to be SRE (Outback Ecology, 2011c – Appendix 10.52). In the original and follow up surveys, neither species has been found to be restricted to within Project area, and *Urodacus 'yeelirrie'* is known to occur at the Yeelirrie mine 70 km to the south-west of Millipede (Outback Ecology, 2011c – Appendix 10.52).

Figure 10.3 outlines the locations of SRE recovered in the immediate vicinity of the Millipede tenements, as well as at Centipede. Of the two species found, one (*Urodacus 'yeelirrie'*) was also found to the west, outside the impact area. The species found only at the proposed site of the processing plant, *Aname MYG177*, has a widespread distribution outside of planned disturbance areas. This species has been found at Lake Way and also at Lake Maitland (Engenium, 2015 – Appendix 10.8).

Figure 10.3: Habitats and SRE records – Millipede



10.5 Existing Environment – Haul Road

The haul road between Lake Maitland and the processing plant location is in the eastern Murchison subregion. The region is characterised by extensive areas of red sandplains and breakaway complexes consist of minimal dune development. Vegetation is dominated by mulga woodlands often rich in ephemerals: hummock grasslands, saltbush shrublands and *Halosarcia* shrublands. The climate is arid and receives 200 mm of rainfall annually, mainly in winter. The subregion is characterised by its internal drainage, with salt lake systems associated with the occluded palaeodrainage system (Ecologia, 2015a – Appendix 10.36).

10.5.1 Land Systems – Haul Road

Land systems in the region have been identified as part of the flora and vegetation key environmental factor and have been addressed in Section 9.4. A summary of the land systems potentially impacted by the haul road is presented in Table 10.9. The study area incorporated 16 land systems. The Bullimore land system has the greatest extent in the study area, occupying 52.5% (3,564,992 ha) of the total study area. Each of the 16 land systems is well represented outside the study area (Ecologia, 2015b – Appendix 10.4).

Table 10.9: Land systems potentially impacted by the haul road

Land System	Description	Total Mapped Area in the Murchison IBRA (ha)	Area in Study Area (ha)	Proportion of Study Area (%)	% Total Extent of the Study Area
Ararak	Broad plains with mantles of ironstone gravel supporting mulga shrublands with wanderrie grasses.	149,889	12.00	0.57	0.008
Bevon	Irregular low ironstone hills with stony lower slopes supporting mulga shrublands.	224,793	0.67	0.03	0.001
Bullimore	Extensive sand plains supporting spinifex hummock grasslands.	3,564,992	1,106.83	52.49	0.031
Carnegie	Salt lakes with extensively fringing saline plains, dunes and sandy banks, supporting low halophytic shrublands and scattered tall *Acacia* shrublands; lake beds are highly saline; gypsiferous and mainly unvegetated.	1,185,945	121.89	5.78	0.01
Cunyu	Calcrete platforms and intervening alluvial floors and minor areas of alluvial plains, including channels with *Acacia* shrublands and minor halophytic shrublands.	290,394	29.91	1.42	0.01
Cyclops	Saline alluvial plains with numerous drainage foci and sandy banks, supporting halophytic shrublands.	25,394	59.18	2.81	0.232
Darlot	Salt lakes and fringing saline alluvial plains, with extensive, regularly arranged sandy banks and numerous claypans and swamps, supporting halophytic shrublands and spinifex and wanderrie grasslands.	133,509	133.46	6.33	0.1
Desdemona	Extensive plains with deep sandy or loamy soils supporting mulga and wanderrie grasses.	255,706	68.25	3.24	0.027

Land System	Description	Total Mapped Area in the Murchison IBRA (ha)	Area in Study Area (ha)	Proportion of Study Area (%)	% Total Extent of the Study Area
Gabinintha	Ridges, hills and footslopes of various metamorphosed volcanic rocks (greenstones), supporting sparse *Acacia* and other mainly non-halophytic shrublands.	165,108	100.22	4.75	0.061
Mitchell	Sandplains, wanderrie banks and saltflats, supporting mulga and mallee shrublands with wanderrie grasses and spinifex, chenopod shrublands on saline plains.	26,622	63.68	3.00	0.238
Monk	Hardpan plains with occasional sandy banks supporting mulga tall shrublands and wanderrie grasses.	996,800	82.01	3.89	0.008
Ranch	Hardpan plains and prominent broad drainage tracts supporting dense mulga shrublands.	86,989	69.70	3.31	0.08
Wiluna	Low greenstone hills with occasional lateritic breakaways and broad stony slopes, lower saline stony plains and broad drainage tracts; supporting sparse mulga and other *Acacia* shrublands with patches of halophytic shrubs.	252,597	126.82	6.01	0.05
Windara	Gently undulating stony plains and low rises with quartz mantles on granite, supporting *Acacia Eremophila* shrublands.	227,972	78.32	3.71	0.034
Yandil	Flat hardpan wash plains with mantles of small pebbles and gravels; supporting groved mulga shrublands and occasional wanderrie grasses.	465,955	5.85	0.28	0.001
Yanganoo	Almost flat hardpan wash plains, with or without small wanderrie banks and weak groving; supporting mulga shrublands and wanderrie grasses on banks.	1,967,110	50.25	2.38	0.003

10.5.2 Fauna Habitat – Haul Road

Outback Ecology identified six broad habitat types during its assessment of Lake Maitland (Outback Ecology, 2009a – Appendix 10.16). Five of the habitats identified were extrapolated across the survey area; however, one habitat was identified in the current survey that did not match the Outback survey (Ecologia, 2015b – Appendix 10.4).

The six habitats identified as occurring across the haul road alignment are:

- Mulga over spinifex sandplain;
- Mulga over stony tussock grassland;
- Mallee/mulga over spinifex sandplain;
- *Melaleuca* woodland over calcrete flats;
- Stoney hills and footslopes; and
- Low halophytic shrubland.

Of the six broad habitats identified, the three mulga-dominated habitats were the most common and accounted for 91.2% of the total study area (Ecologia, 2015b – Appendix 10.4). This habitat is important as it has the potential to support the Brush-tailed Mulgara. The total area of each habitat along the haul road is presented in Table 10.10. The location of each habitat type is shown in Figure 10.4 to Figure 10.7.

Table 10.10: Summary of fauna habitat types

Habitat	Area inside the Study Area (ha)	Percentage of the total area (%)
Mulga over spinifex sandplain	622.9	29.5
Mulga over stony tussock grassland	550.9	26.1
Mallee/mulga over spinifex sandplain	807.6	38.3
Melaleuca woodland over calcrete flats	9.89	0.47
Stony hills and footslopes	79.4	3.77
Low halophytic shrubland	37.9	1.80

Figure 10.4: Fauna habitat section A – ore haul road

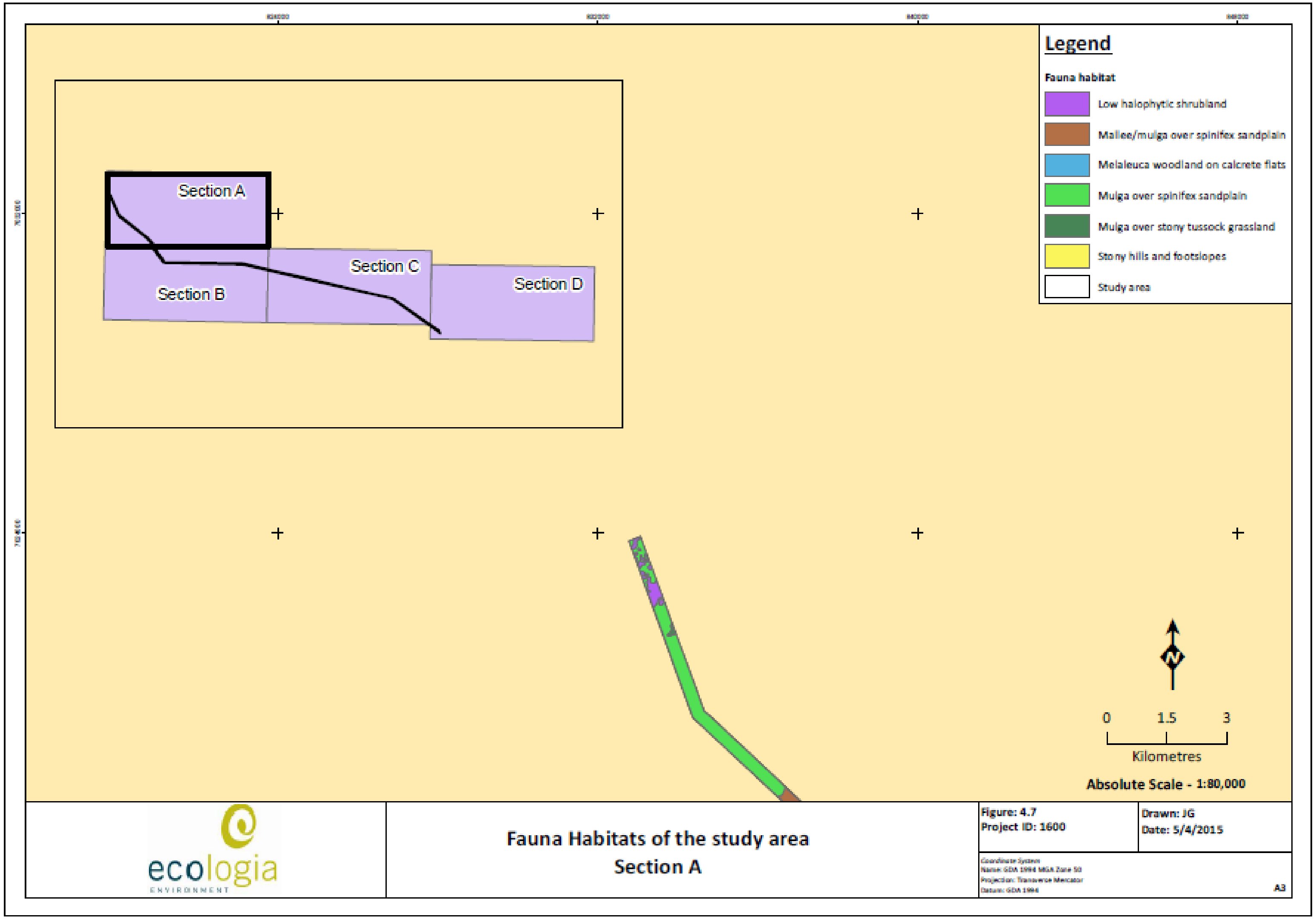


Figure 10.5: Fauna habitat section B – ore haul road

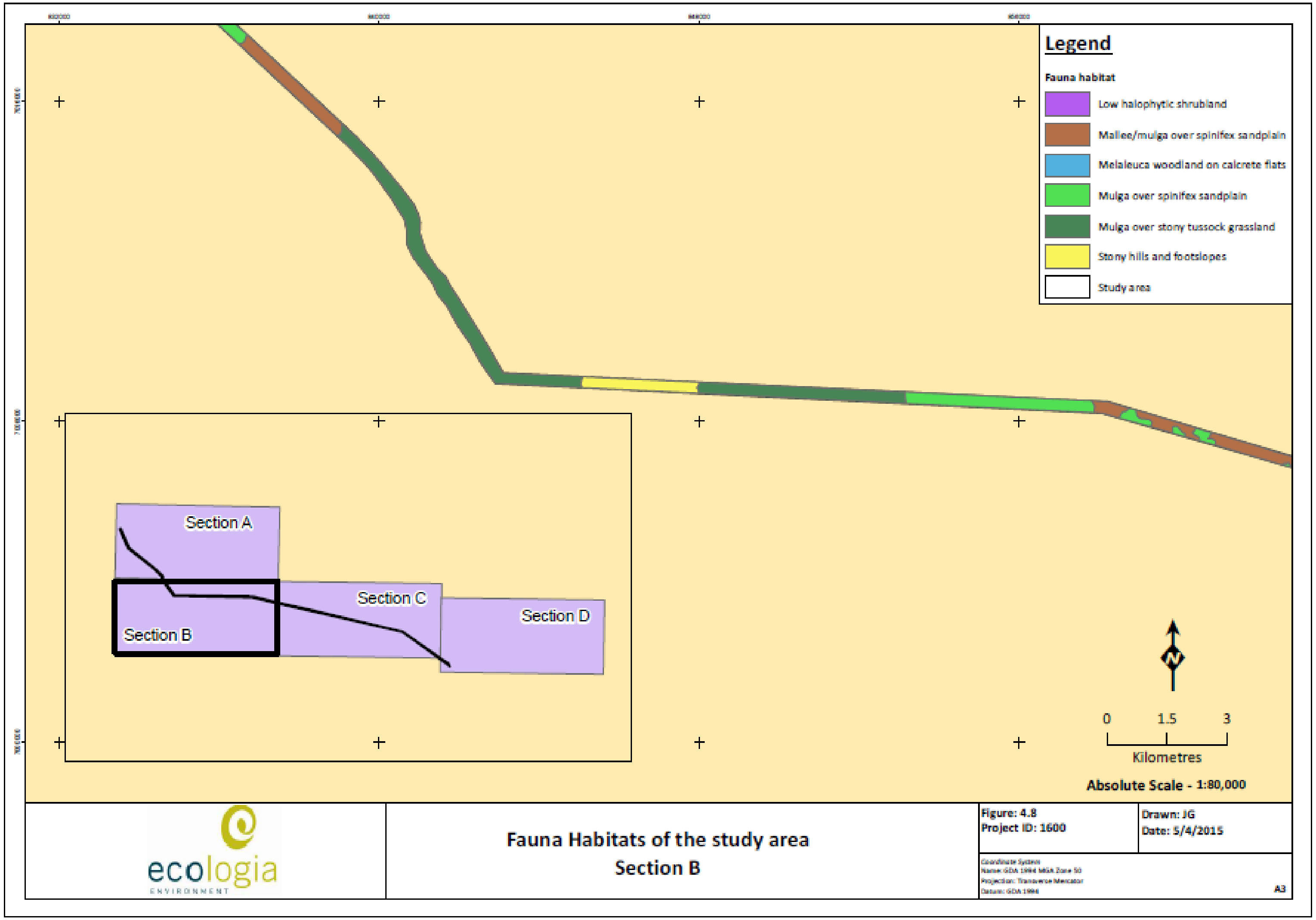


Figure 10.6: Fauna habitat section C – ore haul road

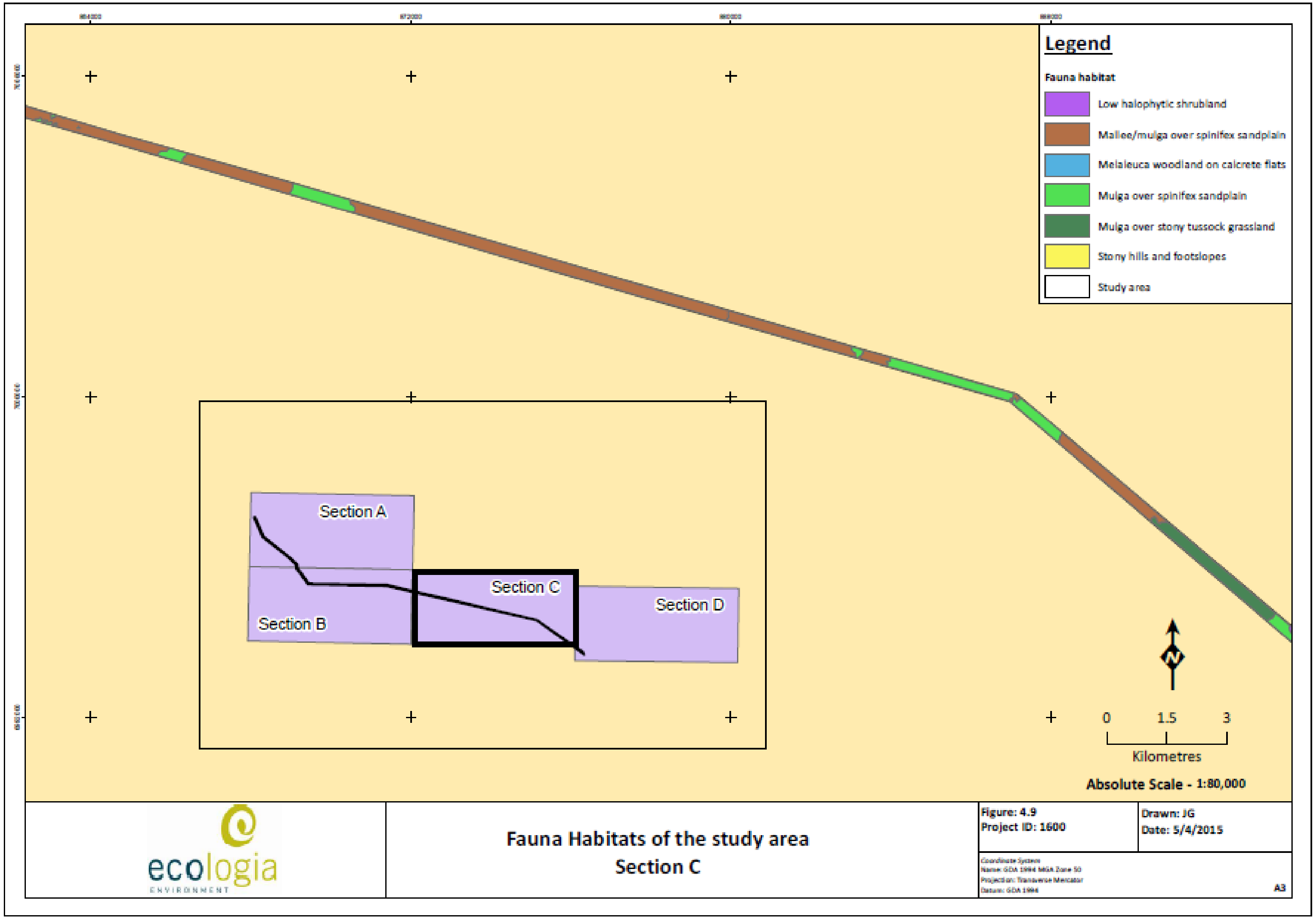
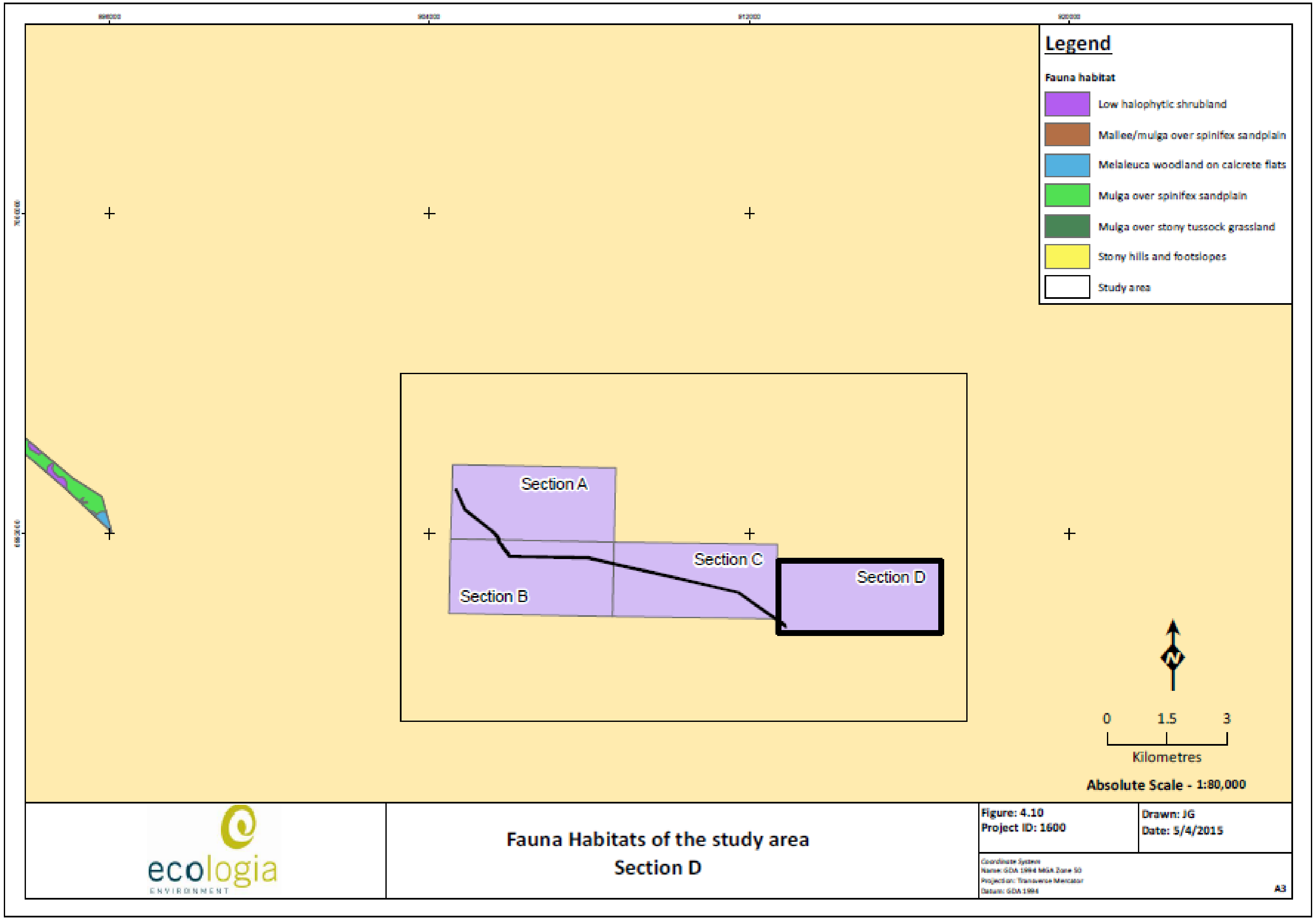


Figure 10.7: Fauna habitat section D – ore haul road



10.5.3 Fauna Assemblages – Haul Road

A total of 14 native and six introduced mammal, 56 bird and 35 reptile species were recorded during the most recent fauna assessment. No amphibians or freshwater fish were recorded (Ecologia, 2015b – Appendix 10.4). A summary of the survey results is provided below. The location of each species recorded in the survey is available in the Millipede to Lake Maitland Haul Road Level 2 Vertebrate Fauna and Fauna Habitat Assessment (Ecologia, 2015b – Appendix 10.4).

Mammals

The native mammal assemblage consisted of five bat species, four dasyurids (small, carnivorous marsupials), two macropods (kangaroos), and three murids (mice). Murids and dasyurids were captured in pitfall and Elliott traps at systematic trapping sites. Macropods were observed during diurnal and nocturnal road spotting. Bats were identified from calls recorded on SM2BAT systems.

The most commonly recorded terrestrial mammal species was the Spinifex Hopping Mouse (*Notomys alexis*) with 40 trap captures recorded across five sites. Of the five bat species recorded during the survey, the most widespread were Gould's Wattled Bat (*Chalinolobus gouldii*; five sites) and Lesser Long-eared Bat (*Nyctophilus geoffroyi*; four sites).

Birds

In total, 56 species of bird were recorded within the study area during the fauna assessments, with a further seven species recorded in close proximity to the study area. In general, bird abundance and activity was low during both the Level 1 reconnaissance and Level 2 surveys. Bird activity was higher during the Level 1 re-alignment survey, most likely as a consequence of the rainfall in the area just prior to the survey. The most widespread species recorded during systematic surveys were Singing Honeyeater (seven sites); Chestnut-rumped Thornbill, Crested Bellbird, Rufous Whistler and Willie Wagtail (six sites); and Black-faced Woodswallow, Grey Butcherbird, Yellow throated Miner and Zebra Finch (five sites). Eight species were only recorded at a single site during the systematic surveys (Australian Magpie, Black-faced Cuckoo-shrike, Common Bronzewing, Galah, Hooded Robin, Redthroat, Variegated Fairy-wren and White-winged Triller).

Herpetofauna

The reptile assemblage of the study area consisted of 11 skinks, seven geckos, seven dragons, five varanids, three elapods and two pygopods. No amphibian species were recorded. The most widespread species recorded during the systematic trapping included: *Ctenotus leonhardii* (six sites); *Ctenotus helenae* (now *C. inornatus*), *Gehyra variegata*, *Menetia greyii* and *Rhynchoedura ornata* (five sites); *Ctenophorus isolepis* and *Lerista derertorum* (four sites). Five species were only recorded once during the survey. They were Mulga Dragon (*Caimanops amphiboluroides*), Burton's Legless Lizard (*Lialis burtonis*), *Lucasium squarrosum*, Jan's Banded Snake (*Simoselaps bertholdi*) and Stripe-tailed Monitor (*Varanus caudolineatus*).

Table 10.11: Fauna recorded – Haul Road

Family	No. of native species	No. of conservation significant species	Family	No. of native species	No. of conservation significant species
Native mammals					
Dasyuridae	4	1	Macropodidae	2	0
Vespertilionidae	3	0	Molossidae	2	0
Muridae	3	0			

Family	No. of native species	No. of conservation significant species	Family	No. of native species	No. of conservation significant species
Birds					
Casuariidae	1	0	Cuculidae	1	0
Columbidae	2	0	Meropidae	1	1
Ptilonorhynchidae	1	0	Accipitradae	2	0
Maluridae	4	0	Acanthizidae	8	0
Accipitridae	2	0	Pachyecephalidae	3	0
Falconidae	3	0	Artamidae	5	0
Rallidae	2	0	Rhipiduridae	1	0
Otididae	1	1	Corvidae	2	0
Cacatudae	1	0	Petroicidae	2	0
Megaluidae	1	0	Cacdatudae	1	0
Estrildidae	1	0	Psittacidae	4	0
Motacillidae	1	0	Meliphagidae	5	0
Pomatostomidae	1				
Reptiles					
Agamidae	7	0	Pygopodidae	2	0
Diplodactylidae	4	0	Scincidae	11	0
Carphodactylidae	1	0	Varanidae	5	0
Gekkonidae	2	0	Elpidae	3	0

10.5.4 Conservation Significant Fauna – Haul Road

Based on database searches and previous studies of the region, 17 conservation significant fauna species listed in Table 10.12 were identified as having the potential to occur in the Project area, with eight of these species being assessed as having a medium to high likelihood of occurring (Ecologia, 2015b – Appendix 10.4).

Table 10.12: Conservation significant fauna occurring or potentially occurring – Haul Road

Species	Conservation Significance EPBC Act	 WC Act	 DPaW	Habitat	Previous Records	Likelihood of Occurrence
Mammals						
Northern Marsupial Mole *Notoryctes caurinus*	EN	S1	EN	Primarily in sand dunes and sandy soils along river flats (DoE 2015), generally not in dune swales or flats, probably due to greater sand compaction (Pavey *et al.* 2012).	Recorded from DoE Protected Matters database search only, which states that the species, or suitable habitat for the species, is likely to occur within the region. However no previous records exist within 100 km of the study area.	**LOW** No records within 100 km of the study area. Study area does not contain any suitable habitat (sand dunes or river flats). As well as the survey results reported by Ecologia 2015b, Appendix 10.4, the Northern Marsupial Mole was also targeted through trench digging and searching for burrows within suitable habitat at Lake Maitland, consistent with DSEWPaC (2011) guidelines. The trench was dug to a depth of one metre in sand dune habitat targeting evidence of the Northern Marsupial Mole. Neither this survey, nor previous surveys in the area, have recorded the species. (Engenium, 2015 – Appendix 10.8)
Golden Bandicoot (Barrow Island) *Isoodon auratus barrowensis*	VU	S1		Rocky sandstone spinifex and vine thickets.	Translocated population occurs in the vicinity at Lorna Glen Station (DoE 2014), approximately 100km north-east of the study area.	**LOW** Not known to occur within the region, with the exception of a translocated population at Lorna Glen Station.
Burrowing Bettong *Bettongia lesueur lesueur*	VU	S1	VU	On the mainland, warrens were constructed in deep soils including loams, low lying areas between dunes, slight outcrops and rises in salt lake systems and under boulders and capping rock.	DoE states that the species, or suitable habitat for the species, is likely to occur within the region.	**LOW** No recent records in the area and currently considered extinct on mainland Australia aside from fenced translocated populations (van Dyck and Strahan 2008).

Species	Conservation Significance EPBC Act	WC Act	DPaW	Habitat	Previous Records	Likelihood of Occurrence
Black-flanked Rock-wallaby *Petrogale lateralis lateralis*	VU	S1	VU	Scattered locations amongst rocky outcrops.	One record c. 60 km to the south-west of the study area in 2009 (DPaW 2015).	**LOW** Only a single record within 100 km of the survey area, and no suitable habitat located within the study area.
Brush-tailed Mulgara *Dasycercus blythi*			P4	Sand plains and gibber plains with moderately dense spinifex with 'runways' between clumps.	Mulgara recorded from the Lake Maitland area by Outback Ecology (2009a - Appendix 10.16) presumed to represent this taxon, and numerous records within the vicinity of the survey area (DPaW 2015).	**RECORDED** Two individuals captured within the study area during the Level 2 survey, and further detections on motion cameras. Secondary evidence (burrows, tracks and scats) detected on both Level 1 surveys and the Level 2 survey.
Long-tailed Dunnart *Sminthopsis longicaudata*			P4	Rocky, hilly areas vegetated with spinifex; occasionally open areas with a stony, rocky mantle.	Recorded in 2011 from hills 40km north-west of the study area (DPaW 2015).	**MEDIUM** Recent records within 40km of the study area. Suitable habitat exists within the limited stony hills and footslopes habitat type.
Birds						
Malleefowl *Leipoa ocellata*	VU	S1	VU	Dry inland scrub, mallee.	A number of records from the region, including three records within 20 km of the study area (DPaW 2015).	**MEDIUM** A number of recent records from the vicinity of the study area. Habitat within the study area lacking the dense vegetation and leaf-litter required for nesting habitat.
Princess Parrot *Polytelis alexandrae*	VU		P4	Sandy deserts; lightly wooded country, including desert oak, open mallee-spinifex and open marble gum woodland.	DoE states that the species, or suitable habitat for the species, may occur within the region. One old record (1964) from c. 40km south-west of the study area (DPaW 2015).	**LOW** No recent records from the vicinity of the study area and habitat within the study area of limited suitability for the species.

Species	Conservation Significance			Habitat	Previous Records	Likelihood of Occurrence
	EPBC Act	WC Act	DPaW			
Fork-tailed Swift *Apus pacificus*	M	S3		Nomadic, almost entirely aerial lifestyle over a variety of habitats; associated with storm fronts.	DoE states that the species, or suitable habitat for the species, is likely to occur within the region.	**MEDIUM** Although there are no records within the vicinity of the study area, this species is highly nomadic, and may occasionally pass over the study area in association with storm fronts.
Eastern Great Egret *Ardea modesta*	M	S3		Wide range of wetland habitats, including floodwaters, rivers, shallows of wetlands, intertidal mudflats.	DoE states that the species, or suitable habitat for the species, is likely to occur within the region.	**LOW** No nearby records and little suitable habitat within the study area.
Oriental Plover *Charadrius veredus*	M	S3		Open plains, including samphire; bare rolling country; bare claypans; open ground near inland swamps.	DoE states that the species, or suitable habitat for the species, may occur within the region.	**LOW** Limited suitable habitat exists within the study area. Generally an uncommon species within the region.
Sharp-tailed Sandpiper *Calidris acuminate*	M	S3		Coasts and well-watered parts of the interior. Prefer grassy areas of non-tidal fresh or brackish wetlands, coastal marshes and tidal flats.	One record from a previous survey in the region (Outback Ecology, 2011b – Appendix 10.18)	**LOW** Recent record in the vicinity of the study area but little suitable habitat within the study area itself.
Rainbow Bee-eater *Merops ornatus*	M	S3		Open country, most vegetation types, dunes, banks; prefer lightly wooded, preferably sandy, country near water.	Recorded on a number of previous surveys in the region and several records from the region (DPaW 2015).	**RECORDED** Recorded from three locations within the study area during the current survey.
Grey Falcon *Falco hypoleucos*		S1	VU	Lightly wooded coastal and riverine plains.	One recent record from c. 70 km north of the study area (*ecologia* internal database).	**HIGH** Recent record to the north of the study area, with suitable habitat present in the study area. This species is likely to be at least an occasional visitor to the study area, but unlikely to nest due to a lack of suitable nesting structures.

Species	Conservation Significance			Habitat	Previous Records	Likelihood of Occurrence
	EPBC Act	WC Act	DPaW			
Peregrine Falcon *Falco peregrinus*		S4	Other	Widespread; coastal cliffs, riverine gorges and wooded watercourses.	Two records within 50 km of the survey area to the south, and recorded widely across the region (DPaW 2015).	**HIGH** Two records relatively near the study area and suitable habitat present within the study area. This species is likely to be at least an occasional visitor to the study area, but unlikely to nest due to a lack of suitable nesting structures.
Australian Bustard *Ardeotis australis*			P4	Open grasslands, chenopod flats and low heathland.	Recorded on a number of previous surveys in the region and several records from within 100 km of the study area (DPaW 2015).	**RECORDED** Recorded during this assessment and suitable habitat present throughout study area.
Reptiles						
Great Desert Skink *Liopholis kintorei*	VU	S1	VU	Desert mosaic landscapes with vegetation of different ages.	DoE states that the species, or suitable habitat for the species, may occur within the region. One old record (1964) approximately 40 km south-west of the study area (DPaW 2015).	**LOW** No recent records of the species close to the study area, and limited suitable habitat within the study area.

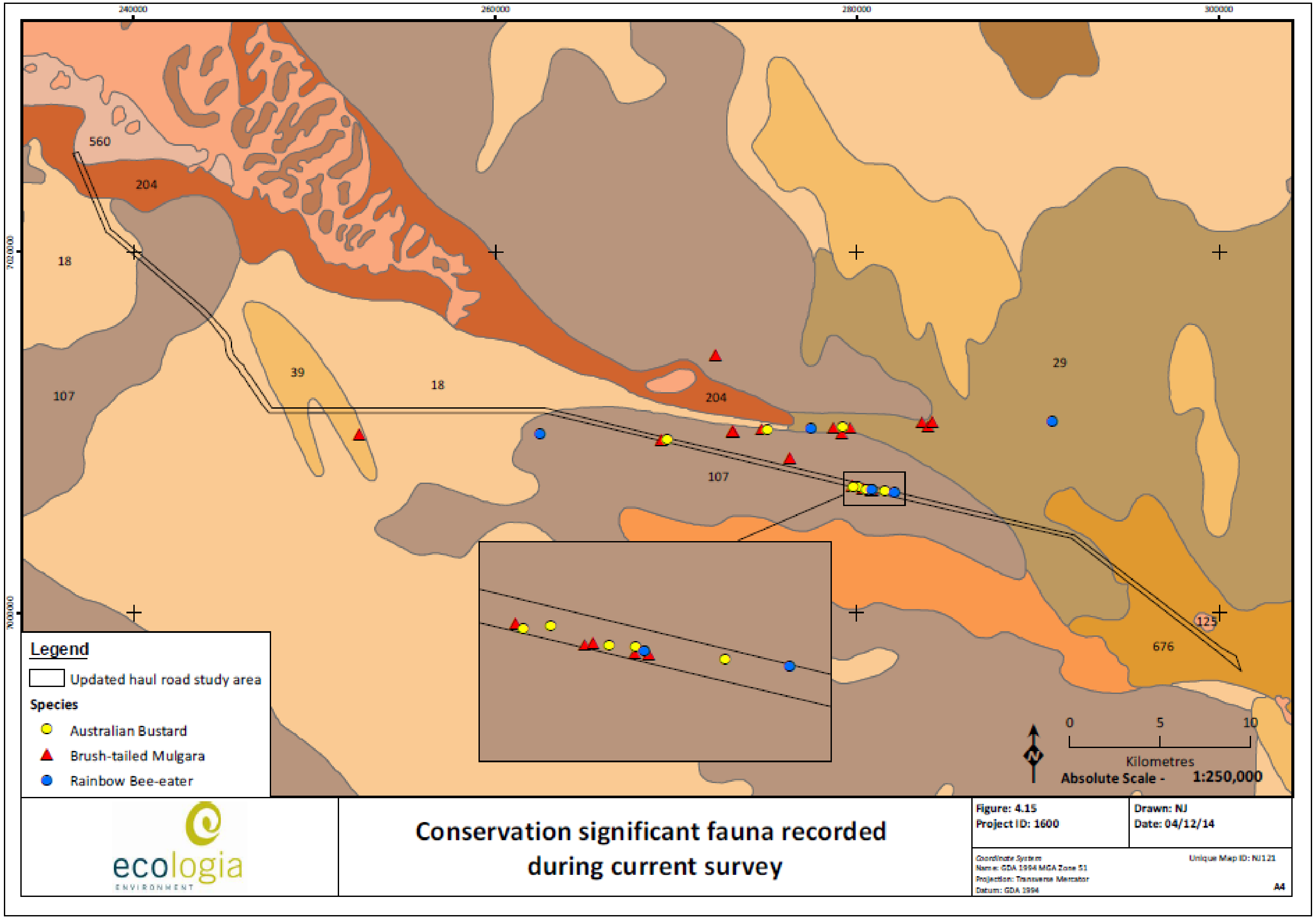
During the survey, three species of conservation significance (one mammal and two birds) were recorded from within the study area. The details of the recordings of conservation significant fauna are presented in Table 10.13, and the location of conservation significant fauna is presented in Figure 10.8.

Table 10.13: Conservation significant fauna recorded during the survey – Haul Road

Species	Location			Comments
	Easting	Northing	Site	
Mammals				
Brush-tailed Mulgara *Dasycercus blythi*	273116	7010034	TE 056	Diggings/tracks/scratchings
	283938	7014494	TE S6	Diggings/tracks/scratchings
	273102	7010043	TE 0S6	Diggings/tracks/scratchings
	279177	7010295	TE 0S 24	Diggings/tracks/scratchings
	274930	7010181	TE OS 4	Diggings/tracks/scratchings
	283918	7010370	TE S6	Female captured in trap
	279117	7010241	TE MC4	Recorded on motion Camera
	252454	7009908	TE MC5	Recorded on motion Camera
	279117	7010241	TE MC4	Recorded on motion Camera
	273116	7010034	TE SMC6	Recorded on motion Camera
	283850	7010483	TE S6	Male captured in Elliot Trap
	269369	7009607	TE S5	Diggings/tracks/scratchings
	272171	7014273	Opportunistic	Female captured during nocturnal survey
	279766	7007007	TE OS30	Active burrows and diggings
	280825	7006829	TE OS31	Burrows and diggings
	280315	7006884	TE MC 9	Captured on motion camera
	280746	7006814	TE MC11	Captured on motion camera
	280384	7006901	Opportunistic	Possible tracks
	276250	7008626	Opportunistic	Diggings and burrows
Birds				
Australian Bustard *Ardeotis australis*	279177	7010259	TE OS24	Tracks only
	274930	7010593	TE OS4	Tracks only
	269369	7009607	TE S5	Tracks only
	280027	7007053	Opportunistic	Two individuals seen
	281519	7006762	Opportunistic	Tracks only
	280742	7006837	Opportunistic	Tracks only
	279766	70070007	TE OS30	Tracks only
	280825	7006829	TE OS31	Tracks only

Species	Location			Comments
	Easting	Northing	Site	
	280524	7006882	Opportunistic	Numerous tracks in area
	270965	7009303	TE OS40	Tracks only
Rainbow Bee-eater *Merops ornatus*	277477	7010259	Opportunistic	Two individuals
	290816	7010593	TE S7	Two individuals
	262470	7009930	TE S4	One individual
	280825	7006829	TE OS31	Two individuals
	282070	7006707	TEOS27	Two individuals

Figure 10.8: Locations of conservation significant fauna recorded on Haul Road alignment



10.5.5 Short-range Endemic Fauna – Haul Road

Toro commissioned Ecologia to undertake a desk top assessment of SRE invertebrate fauna potentially affected by establishment of the haul road (Ecologia, 2015f – Appendix 10.2).

Ecologia reviewed previous fauna surveys and concluded there is a relatively high level of existing knowledge about SRE fauna in the region.

A total of 107 invertebrate taxa from SRE groups have been identified as potentially occurring within the study area. Of these, 54 are considered to be potential SREs according to the guidelines of the Western Australian Museum, although these guidelines assign potential SRE status to any taxon which is poorly understood taxonomically, or cannot be identified to species level or equivalent.

Those taxa considered most likely to represent true SRE taxa are:

- Mygalomorph spiders: *Aname* 'sp. B', *Aname* MYG176, *Aname* MYG227, *Kwonkan* MYG175, *Kwonkan* MYG194
- Scorpions: *Urodacus* 'lakeway1', *Urodacus* 'lakeway2', *Urodacus* 'maitland1', *Urodacus* 'maitland2', *Urodacus* 'yeelirrie'
- Pseudoscorpions: *Beierolpium* 'sp. 8/2', *Beierolpium* 'sp. 8/3', *Beierolpium* 'sp. 8/4 small', *Linnaeolpium* sp., *Xenolpium* 'PSE064'
- Isopods: *Acanthodillo* sp. nov. 7, *Buddelundia* sp. nov. 46, *Cubaris* sp. wiluna, *Pseudodiploexochus* sp. nov., Isopoda nov. genus nov. species (Ecologia 2015f – Appendix 10.2)

10.6 Existing Environment – Lake Maitland

Lake Maitland lies within the East Murchison Subregion of the Murchison IBRA. This subregion has extensive areas of red sandplains and breakaway complexes consisting of minimal dune development with vegetation dominated by mulga woodlands often rich in ephemerals, hummock grasslands, saltbush shrublands and *Halosarcia* shrublands.

10.6.1 Land Systems

The land systems in the Lake Maitland study area have been discussed in Section 9.4 and are shown in Figure 9.2. Table 10.14 describes the six land systems that occur within the study area: Bullimore, Cunyu, Darlot, Desdemona, *Melaleuca* and Mileura.

Table 10.14: Land systems in the study area

Land System	Description	Extent Within the Study Area (ha)	Proportion of Study Area (%)	Mapped Extent in the Murchison (ha)	Proportion in Study Area (ha)
Darlot	Salt lakes and fringing saline alluvial plains, with extensive, regularly arranged sandy banks and numerous claypans and swamps, supporting halophytic shrublands and spinifex and wanderrie grasslands.	3,283	51.0	133,509	2.459
Mileura	Saline and non-saline calcreted river plains, with clayey flood plains interrupted by raised calcrete platforms supporting diverse and very variable tall shrublands, mixed halophytic shrublands and shrubby grasslands.	1,466	22.8	206,496	0.710
Cunya	Calcrete platforms and intervening alluvial floors and minor areas of alluvial plains, including channels with *Acacia* shrublands and minor halophytic shrublands.	923.5	14.4	290,394	0.318
Bullimore	Extensive sand plains supporting spinifex hummock grasslands.	740.0	11.5	3,564,992	0.021
Melaleuca	Sandy-surfaced plains and calcareous plains supporting spinifex or mulga wanderrie shrublands.	15.01	0.23	37,625	0.04
Desdemona	Extensive plains with deep sandy or loamy soils supporting mulga and wanderrie grasses.	6.683	0.1	255,706	0.003

10.6.2 Fauna Habitat

A total of eight broad fauna habitats were identified as occurring within the study area (Engenium, 2015 – Appendix 10.8). They were identified as:

- Low halophytic shrubland;
- *Triodia* plurinervata on lake edge;
- Open calcrete plain;
- Mallee/mulga over spinifex;
- Woodland on calcrete plain;
- Mulga woodland;
- Open spinifex sandplain; and
- Kopi dune.

All the habitat types within the study area were assessed as being in good to very good condition. With the exception of the *Triodia plurinervata* habitat, all the habitats are well represented throughout the Murchison region.

The low halophytic shrubland habitat type covers 37.6% of the study area. This habitat type is characterised by low, moderately open shrubland of chenopods such as *Maireana* and *Tecticornia* on clay flats on the lake bed, interspersed with occasional low sandy dunes with an open cover of *Lawrencia* shrubland. The clay substrate is suitable for burrowing reptiles. Leaf and wood litter is absent. After rainfall, some areas within this habitat type flood, creating wetland habitat suitable for waterbirds and migratory waders. Lake Maitland is situated within an expansive network of salt lake systems.

The *Triodia plurinervata* on lake edge habitat type covers 6.8% of the study area. This habitat type is characterised by dense hummocks of *Triodia plurinervata* interspersed with a sparse to moderately dense shrub layer comprising *Acacia*, *Grevillea*, *Eremophila* and blue bush species, and isolated mulga trees. Substrate comprised orange sand or sandy clay, suitable for burrowing. Leaf and wood litter is present, but limited to under trees and shrubs.

This habitat is seen growing in isolated islands fringing the salt lake. Due to its isolation from surrounding habitats, pockets of *Triodia plurinervata* on lake edge habitat type contains spinifex that is notably mature. It is estimated many areas are greater than 20 years fire age and, as a result, hummocks are tall, long and continuous. The mature age of this spinifex is not common in the Eastern Murchison region and is therefore important in supporting local vertebrate fauna.

The open calcrete plain habitat type covers 12.8% of the study area. This habitat type is characterised by flat plains of orange clay interspersed with calcrete. The habitat is very open, with a very low ground cover of native grasses and some chenopods, with sparse shrubs and low trees occurring as lone plants or occasionally in small, isolated stands. Leaf and wood litter is sparse and restricted to the base of trees and shrubs. The open calcrete plain habitat type is found adjacent to and in association with the low halophytic shrubland habitat, and transitions in to the woodland on calcrete plain habitat type.

The mallee/mulga woodland habitat type covers 14.4% of the study area. This habitat type is characterised by open mixed woodland of mallee (*Eucalyptus* sp.) and mulga (*Acacia aneura*), over an open midstorey of *Acacia* shrubs and ground cover of open spinifex (*Triodia basedowii*) on an orange sandy clay substrate. Leaf and wood litter is abundant at the base of mallees, but sparse elsewhere.

The woodland on calcrete plain habitat type covers 22.1% of the study area. This habitat type is characterised by open woodland of *Allocasuarina* and mulga over an open shrub and ground cover layer including a mixture of *Acacia*, *Melaleuca*, *Eremophila*, *Ptilotus*, *Solanum* and blue bush. Substrate is dominated by orange sandy clay with sections of calcrete, with leaf and wood litter present at the base of trees and shrubs.

The mulga woodland habitat type covers 2.1% of the study area. This habitat type is characterised by open to moderately dense mulga (*Acacia aneura*) woodland over sparse low shrubs and spinifex (*Triodia* sp.) hummocks. Substrate is firm orange clay or sandy clay, with sparse leaf and wood litter.

The open spinifex sandplain habitat type covers 2.7% of the study area, occurring as isolated patches in the east of the study area. This habitat type is characterised by moderately dense hummock grassland of *Triodia basedowii* with an open shrub layer of *Acacia*s and scattered mallees. Substrate is orange clay-sand. Leaf litter is sparse, and largely restricted to the base of trees and shrubs.

The kopi dune habitat type covers 1.4% of the study area, occurring primarily on the margins of Lake Maitland in the south of the study area. This habitat type is characterised by raised ridges of gypsum supporting low open eucalypt woodland with a sparse understorey of *Grevillea*, *Lawrencia*, and herbs and grasses. Beds of leaf and wood litter are present around the base of eucalypts.

The extent of the habitat within the study area is presented in Table 10.15. A map of the habitats at Lake Maitland is presented in Figure 10.9 and a map of the borefield habitat is presented in Figure 10.10.

Table 10.15: Broad scale fauna habitats within the study area

Fauna Habitat	Area within the Study Area (ha)	Proportion of the Study Area (%)
Low halophytic shrubland	2,422	37.6
Woodland on calcrete plain	1,425	22.1
Triodia plurinervata on Lake Edge	437	6.8
Open spinifex sandplain	173	2.7
Mulga woodland	136	2.1
Kopi dune	92	1.5
Open calcrete plain	824	12.8
Mallee/mulga over spinifex plain	927	14.4

Figure 10.9: Habitat mapping at Lake Maitland

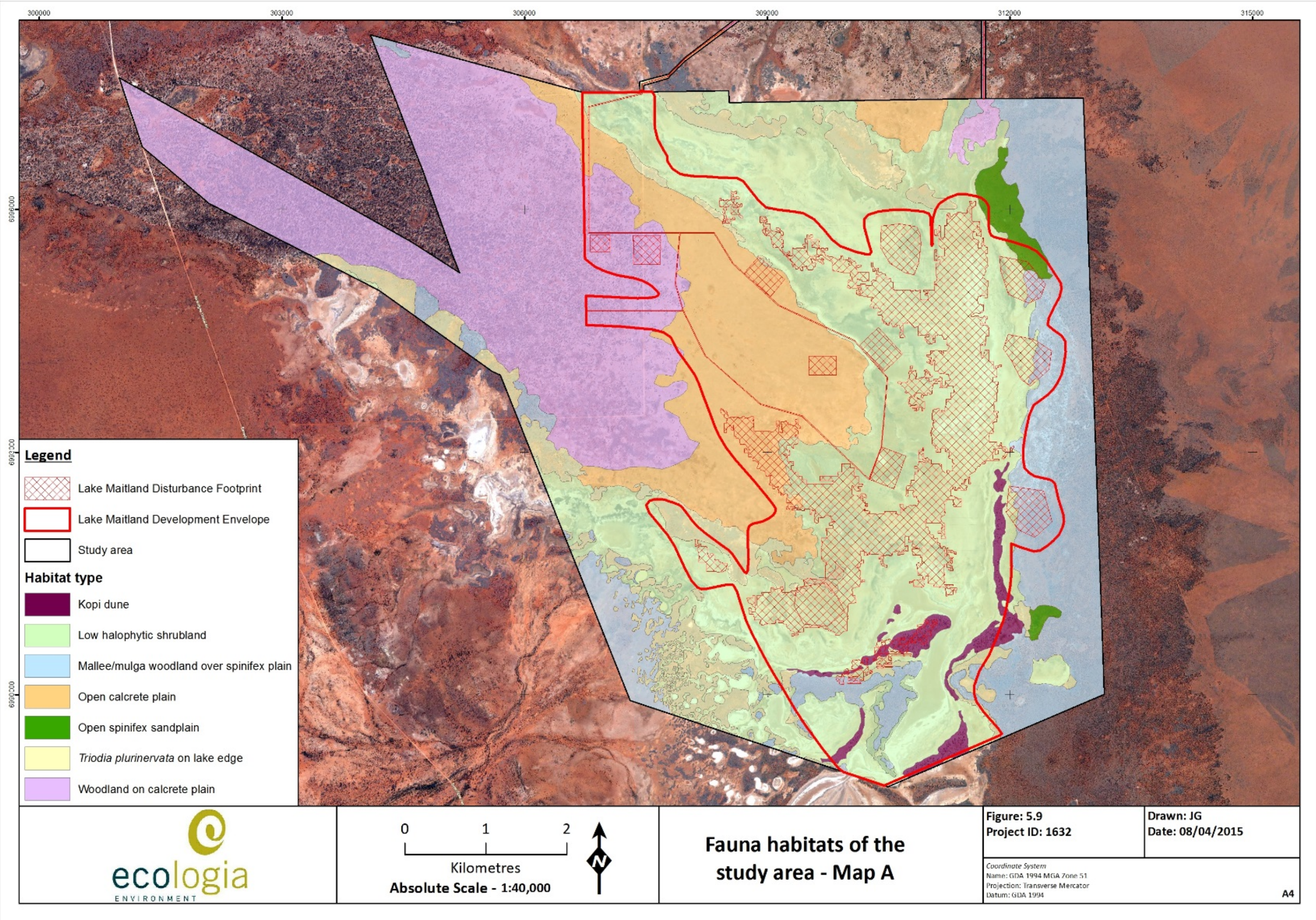
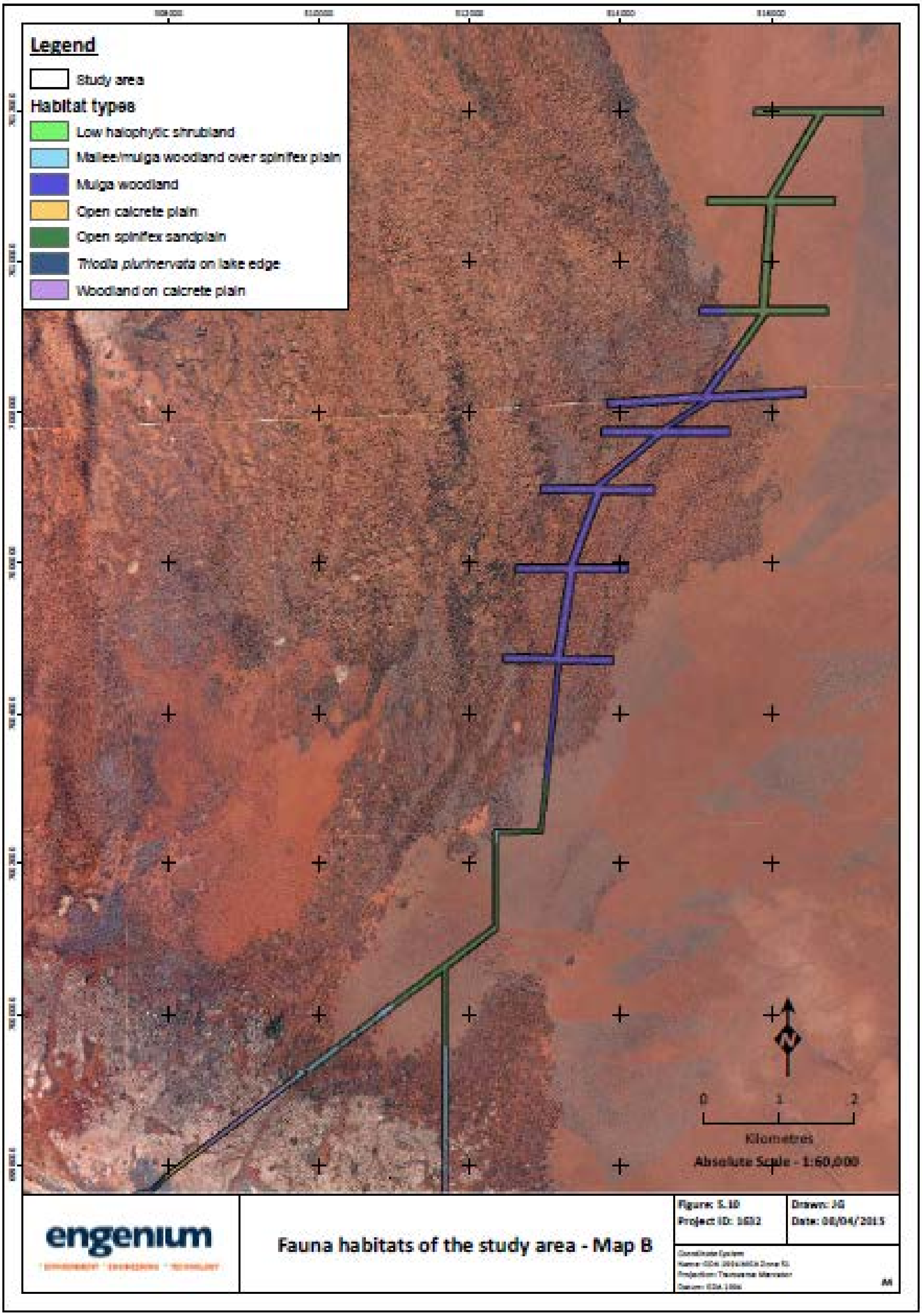


Figure 10.10: Borefield habitat map – Lake Maitland



10.6.3 Fauna Assemblages

The main fauna assemblages are described below and listed in Table 10.16. A full list of fauna locations is in the Lake Maitland Level 2 Vertebrate Fauna and Targeted Reptile Survey Report (Engenium 2015 – Appendix 10.8).

Mammals

A total of 18 native mammal and six introduced mammals were recorded within the study area across the three phases of the most recent survey (Engenium, 2015 – Appendix 10.8). The native mammal assemblages included five dasyurids (e.g. Brush-tailed Mulgara), three rodents (e.g. Spinifex Hopping-mouse), two macropods (e.g. Red Kangaroo), one monotreme (Echidna) and seven bat species. Species counts were only available for phase 3, where the Red Kangaroo was the most abundant species recorded. The open calcrete plain represents excellent foraging habitat for this species and it was regularly encountered browsing on the native grasses.

Particular attention was paid to Mulgara species during the surveys. Motion sensor cameras were placed in the field to sample additional habitat types not covered by the trapping. A total of 12 camera trapping locations were established, which were then left for between two to three days. Evidence of the Brush-tailed Mulgara was found. However, no evidence of the Crest-tailed Mulgara was found.

Targeted surveys were also carried out for the Northern Marsupial Mole (*Notorycetes caurinus*). Where the habitat was considered suitable, trenching was undertaken searching for evidence of burrows. No evidence of the species was found.

Birds

A total of 94 species of bird were recorded within the study area across the three phases of the most recent survey (Engenium, 2015 – Appendix 10.8). Species counts were only available for phase 3. The Masked Woodswallow, a nomadic species, was the most abundant, with a total of 625 individuals recorded. Of the resident bush birds of the study area, the most abundant were White-winged Fairy-wren (131), Orange Chat (113) and Yellow-throated Minor (80).

The total species count for the study area obtained during this survey is high compared to other surveys in the region (Engenium, 2015 – Appendix 10.8). This is largely attributable to the variety of habitat types, prevailing environmental conditions, in particular, the heavy rainfall experienced prior to phase 3 of the survey and associated presence of surface water in ephemeral wetlands within the study area. This is evidenced by the relatively high diversity of waterbird species compared to other surveys in the region (e.g. seven species of ducks and swans were recorded during the current survey, compared to a maximum of two species on previous surveys in the region).

Reptiles

A total of 53 reptile taxa were recorded within the study area. The reptile assemblage included 18 skinks, 13 geckoes, seven snakes (comprising five elapids, one python and one blind snake), six dragons, five varanids (goannas), three legless lizards and one turtle.

The most commonly recorded species was the Salt Pan Dragon, with a total of 85 records exclusively from within the low halophytic shrubland habitat type. Other common species included the skinks *Ctenotus pantherinus* (27) and *Ctenotus inornatus* (23).

The total species count for the study area obtained during this survey is considered high compared to other surveys in the region (Engenium, 2015 – Appendix 10.8). This is likely to be due to the variety of habitats present and favourable environmental conditions. As well as the heavy rainfall in the the study area prior to the phase 3 survey, temperatures remained relatively warm during the first week of the work. This rainfall and temperature combination is likely to have resulted in increased reptile activity. The level of survey effort (three phases) was also higher than that conducted during other surveys in the region.

Despite the relatively high variety of species, the majority of reptiles that were recorded are relatively widespread in Western Australia (DPaW, 2015). The gecko *Underwoodisaurus milii* was recorded several times within the study area during phase 3 of the survey, primarily within the kopi dune habitat type in the south of the study area. This species is approaching the north-eastern limit of its range in WA. The Southern Shovel-nosed Snake, which was recorded once in the east of the study area, is also approaching the northern limit of its range.

Several Flat-shelled Turtles (*Chelodina steindachneri*) were also observed at night in ephemeral pools in the south-west of the study area, supporting a previous anecdotal record noted by Outback Ecology (2009a – Appendix 10.16). This species aestivates underground during dry periods and had been recorded on only one previous survey in the region (Outback Ecology, 2008a – Appendix 10.21), and then only from old shells.

The newly described gecko species *Diplodactylus laevis* (recently separated from *D. conspicillatus*) was recorded during phase 3 of the study, occurring sympatrically with *D. conspicillatus*.

Table 10.16: Fauna species recorded - Lake Maitland

Family	No. of native species	No. of conservation significant species	Family	No. of native species	No. of conservation significant species
Native mammals					
Tachyglossidae	1	0	Macropodidae	2	0
Dasyuridae	5	1	Vespertilionidae	5	0
Molossidae	2	0	Muridae	3	0
Birds					
Casuariidae	1	0	Cuculidae	2	0
Columbidae	3	0	Monarchidae	1	
Podicipedidae	1	0	Tytonidae	1	0
Podargidae	1	0	Ptilonorhynchidae	1	0
Eurostopodidae	1	0	Maluridae	4	0
Aegothelidae	1	0	Acanthizidae	8	0
Accipitridae	7	0	Meliphagidae	10	0
Campephagidae	6	0	Pomatostomidae	2	0
Motacillidae	1	0	Psophodidae	2	0
Falconidae	4	1	Artamidae	5	0
Rallidae	1	0	Rhipiduridae	1	0
Otididae	1	1	Corvidae	2	0
Burhinidae	1	0	Hirundinidae	3	0
Recurvirostridae	2	0	Petroicidae	1	0
Charadriidae	4	0	Megaluridae	2	0
Cacatuidae	3	0	Estrildidae	1	0
Psittacidae	3	0	Anatidae	7	0

Family	No. of native species	No. of conservation significant species	Family	No. of native species	No. of conservation significant species
Reptiles					
Cheluidae	1	0	Pygopodidae	3	0
Agamidae	6	0	Egerniidae	2	0
Diplodactylidae	7	0	Varanidae	5	0
Carphodactylidae	3	0	Typhlopidae	1	0
Gekkonidae	3	0	Elapidae	5	0
Eugongylidae	3	0	Boidae	1	0
Sphenomorphidae	13	0			
Amphibians					
Hylidae	2	0	Limnodynastidae	1	0

Samphire Reptile Assemblage

In the targeted samphire search for reptiles, nine species of reptile were recovered. The assemblage was dominated by the Claypan Dragon (*Ctenophorus salinarum*), accounting for 83 of the total 100 reptile records. This is unsurprising given the species is a samphire specialist that favours saltbush and samphire habitats in association with claypans and salt lakes (Engenium, 2015 – Appendix 10.8).

Few other reptile species were recorded in the samphire habitat proper, with most species occupying microhabitats within the broader habitat type. For example, the next most commonly recorded species were Flat-shelled Turtle *Chelodina steindachneri* (seven records) from ephemeral pools in the south-west and *Lerista bipes* (four records) from an isolated low sandy dune vegetated with *Lawrencia helmsii* within a large area of samphire claypan. The remaining recordings were predominantly generalist species, such as *Gehyra variegata* and *Lialis burtonis*, which occur in a wide range of habitat types. The most unusual species recorded was two records of the Jewelled Gecko *Strophurus elderi* from site LM S6. This species is generally considered to be an obligate spinifex dweller (Engenium, 2015 – Appendix 10.8).

Conservation Significant Fauna

At Lake Maitland, 14 conservation significant fauna species potentially occur as listed in Table 10.17 (Engenium, 2015 – Appendix 10.8). They comprise:

- Five species listed under the Commonwealth EPBC Act and the WA Wildlife Conservation Act:

- Mulgara (*Dasycercus cristicauda* – Vulnerable and Schedule 1);
- Malleefowl (*Leipoa ocellata* – Vulnerable and Schedule 1);
- Slender-billed Thornbill (*Acanthiza iredalei iredalei* – Vulnerable);
- Major Mitchell's Cockatoo (*Cacatua leadbeateri* – Schedule 4); and
- Peregrine Falcon (*Falco peregrinus* – Schedule 4).

- Four priority species listed under the WA DPaW Priority Species List:

- Australian Bustard (Ardeotis australis – P4);
- Bush Stone-curlew (Burhinus grallarius – P4);
- Grey Falcon (Falco hypoleucos – P4); and
- Striated Grasswren (Amytornis striatus striatus – P4).

- Five species listed as Migratory under the EPBC Act:

- Fork-tailed Swift (Apus pacificus pacificus);
- Rainbow Bee-eater (Merops ornatus);
- Great Egret (Ardea alba);
- Oriental Plover (Charadrius veredus); and
- Common Sandpiper (Actitis hypoleucos).

During all surveys for proposed mining at Lake Maitland, three listed species were recorded within the study area: Brush-tailed Mulgara (DPaW Priority 4), Peregrine Falcon (WC Act Schedule 4) and Australian Bustard (DPaW Priority 4). A single male individual Brush-tailed Mulgara (*Dasycercus blythi*) was vouchered at the request of the Western Australian Museum, to aid in ongoing taxonomic resolution of the *Dasycercus* genus.

A further two species are assessed as having a high likelihood of occurrence and five species as having a medium likelihood of occurrence. The remaining four species are considered to have a low likelihood of occurrence within the study area.

Table 10.17: Conservation significant fauna occurring or potentially occurring – Lake Maitland

	Conservation Significance			Habitat	Previous Records	Likelihood of Occurrence
	EPBC Act	WC Act	DPaW			
Mammals						
Northern Marsupial Mole *Notoryctes caurinus*	EN	S1	EN	Primarily in sand dunes and sandy soils along river flats (DoE 2015; Benshemesh and Aplin, 2008; Menkhorst and Knight, 2011), generally not in dune swales or flats, probably due to greater sand compaction (Pavey *et al.* 2012).	Recorded from DoE Protected Matters database search only, which states that the species, or suitable habitat for the species, is likely to occur within the region.	**LOW** The Northern Marsupial Mole was targeted through trench digging and searching for burrows within suitable habitat at Lake Maitland, consistent with DSEWPaC (2011) guidelines. The trench was dug to a depth of one metre in sand dune habitat targeting evidence of the Northern Marsupial Mole. Neither this survey, nor previous surveys in the area, have recorded the species. (Engenium, 2015 – Appendix 10.8)
Black-flanked Rock-wallaby *Petrogale lateralis lateralis*	VU	S1	VU	Varied rocky habitats, including rocky islands, rocky outcrops in mallee, spinifex or arid shrubland, and sandstone gorges (Eldridge and Pearson, 2008: Menkhorst and Knight, 2011)	One record from 2009 in the vicinity of Mout Keith, c60 km west of the study area (DPaW 2015)	**LOW**

	Conservation Significance			Habitat	Previous Records	Likelihood of Occurrence
	EPBC Act	WC Act	DPaW			
Brush-tailed Mulgara *Dasycercus blythi*			P4	Spinifex grasslands, usually on relatively sandy substrates (Wooley 2008)	Large number of records in the region (DPaW 2015) and recorded recently from the Millipede to Lake Maitland haul road study area (Ecologia, 2015b – Appendix 10.4). Mulgara recorded from the Lake Maitland area by Outback Ecology (2009a – Appendix 10.16) also presumed to represent this taxon.	**RECORDED**
Birds						
Night Parrot *Pezoporus occidentalis*	EN	S1	CR	Not well known, but generally accepted to require dense areas of spinifex, often in association with chenopods. (Blyth, 1996)	Several potential recent sight recotds from Lorna Glen, c. 90km north of the study area (N. Hamilton, pers. Comm.). Inland salt lakes of Western Australia are considered to have been a major centre for distribution of the species in the past (Blyth 1996).	**MEDIUM**
Malleefowl *Leipoa ocellata*	VU	S1	VU	Mallee eucalypt woodland, scrubland and other dray woodland/scrubs (Garnett and Crowley, 2000; Johnstone and Storr, 1998).	Several records from the region (most recent 2001), including a cluster in the Mount Keith/Wanjarri NR area (DPaW 2015)	**MEDIUM**
Princess Parrot *Polytelis alexandrae*	VU		P4	Lightly wooded desert country, including desert oak and marble gum woodland (Johnstone and Storr, 1998).	DoE states that the species, or suitable habitat for the species, may occur within the region. One old record (1964) from c. 55km south-west of the study area (DPaW 2015).	**LOW**
Eastern Great Egret *Ardea modesta*	M	S3		Wide range of wetland habitats, including floodwaters, rivers, shallows of wetlands, intertidal mudflats (Johnstone and Storr, 1998).	DoE states that the species, or suitable habitat for the species, is likely to occur within the study area.	**MEDIUM**

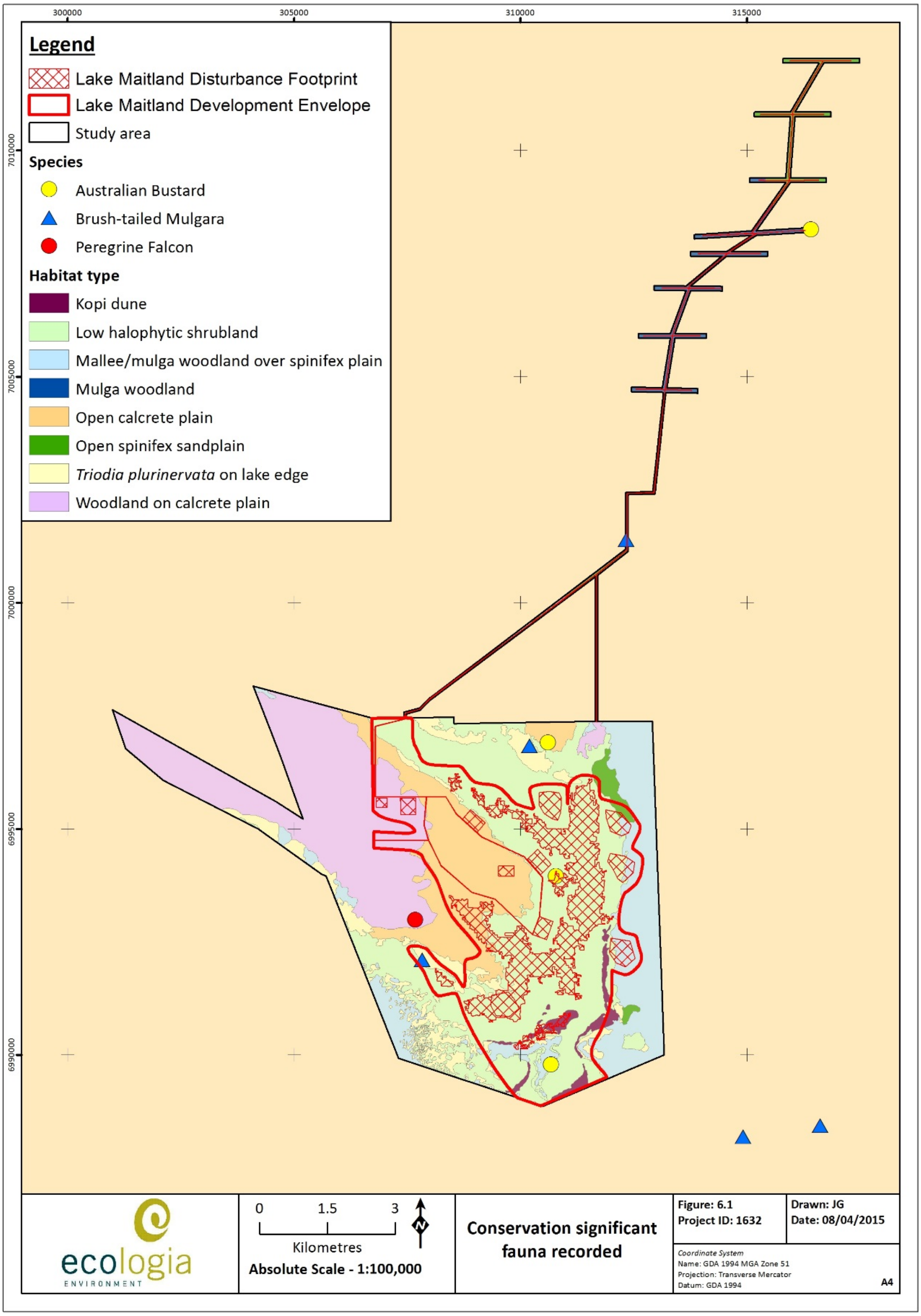
	Conservation Significance			Habitat	Previous Records	Likelihood of Occurrence
	EPBC Act	WC Act	DPaW			
Oriental Plover *Charadrius veredus*	M	S3		Open plains, including samphire; bare rolling country; bare claypans; open ground near inland swamps (Morcombe 2000; Simpson and Day, 2010).	DoE states that the species, or suitable habitat for the species, is likely to occur in the vicinity of the study area (DoE 2015).	**MEDIUM**
Sharp-tailed Sandpiper *Calidris acuminata*	M	S3		Variety of shallow wetland habitats, including tidal mudflats, saltmarsh, shallow inland wetlands (fresh, brackish or saline), sewage ponds (Pizzey *et al.* 2013)	One record from a previous survey in the region (Outback 2011a – Appendix 10.18).	**HIGH**
Rainbow Bee-eater *Merops ornatus*	M	S3		Open country, most vegetation types, dunes, banks; prefer lightly wooded, preferably sandy, country near water Johnstone and Storr, 1998; Pizzey and Knight, 2003).	Several records in the vicinity of Lake Way (c. 80 km NW of the study area), and one record from c. 55 km SE of the study area near Wanjarri NR (DPaW 2015). Recorded on several recent fauna surveys in the region, most notably from the Lake Maitland infrastructure areas (Outback Ecology, 2011b – Appendix 10.18) and the proposed Lake Maitland to Millipede haul road (Ecologia, 2015b – Appendix 10.4)	**HIGH**
Grey Falcon *Falco hypoleucos*		S1	VU	Lightly wooded plains (Johnstone and Storr, 1998), typically nesting in tall trees along watercourses (Garnett and Crowley, 2000).	One recent record from c. 100 km NNW of the study area (Ecologia internal database).	**MEDIUM**

	Conservation Significance			Habitat	Previous Records	Likelihood of Occurrence
	EPBC Act	WC Act	DPaW			
Peregrine Falcon *Falco peregrinus*		S4	Other	Wide variety of habitats; woodlands, treed grasslands, wetlands, timbered watercourses, rocky gorges, cities. Breeds on ledges on cliffs, outcrops, quarries and city buildings, in hollow trees or in abandoned nests of other raptors (Johnstone and Storr 1998; Pizey and Knight, 2003)	Three records within 100 km of the study area and recorded widely across the region (DPaW, 2015)	**RECORDED**
Australian Bustard *Ardeotis australis*			P4	Open grasslands, shrublands, chenopod flats and low heathland (Johnstone and Storr, 1998; Pizzey and Knight, 2003).	Numerous records in the region, particularly in the Wanjarri NR and Mount Keith area, c. 45 km SE of the study area, and c. 80 km N of the study area (DPaW 2015) Also recorded from the proposed Lake Maitland to Millipede haul road (Ecologia, 2015b – Appendix 10.4).	**RECORDED**
Reptiles						
Great Desert Skink *Liopholis kintorei*	VU	S1	VU	Variety of desert habitats, including arid sand flats and clay or loam based soils, vegetated with spinifex (Cogger, 2000; Wilson and Swan, 2010)	DoE states that the species, or suitable habitat for the species, may occur within the region. One old record (1964) from c. 55 km SW of the study area (DPaW 2015).	**MEDIUM**

The locations of conservation significant fauna recorded across Lake Maitland are shown in Figure 10.11.

The Brush-tailed Mulgara is the only mammal of significance recorded in an area to be impacted by the Proposal. However, the haul road and other regional surveys have also recorded this species outside the area of impact, so it is not considered that implementation of the Proposal would significantly affect the species.

Figure 10.11: Locations of conservation significant fauna in the Lake Maitland Project area



Short-range Endemic Species

Across the Lake Maitland deposit, 21 species of SRE have been identified (Engenium, 2015 – Appendix 10.8). These species are:

- *Acanthodillo '7'*
- *Ananippe* sp.
- *Aname 'MYG177'*
- *Aname 'MYG227'*
- *Armadillidae 'reduropoda 1'*
- *Buddelundia '25'*
- *Buddelundia '46'*
- *Cethegus fugax*
- *Cubaris 'wiluna'*
- *Isometroides* sp.
- *Kwonkan 'MYG175'*
- *Kwonkan 'MYG194'*
- *Lineaolpium* sp.
- *Lychas annulatus*
- *Philosclidae cf. Andricophiloscia* sp. indet.
- *Pseudodiploexochus* sp. indet.
- *Spherillo* sp. *indet. (Lake Maitland 1)*
- *Spherillo* sp. *indet. (Lake Maitland 2)*
- *Trichorhina* sp. indet.
- *Urodacus 'yeelirrie'*
- *Urodacus* sp. Indet.

New data from the Western Australian Herbarium has classified *Lychas 'annulatus'* as an SRE species. This species has been recorded previously on many surveys of Western Australia (Engenium 2015 – Appendix 10.8) and so its distribution is not considered to be confined to the area of direct impact from mining at Lake Maitland.

Urodacus sp. indet. was found in the open plain habitat and two specimens were collected. Both specimens were female, meaning the morphological features required to positively identify the species were not present. Accordingly, it is possible the two specimens were from the species *Urodacus 'yeelirrie'* which is recorded throughout the region. The habitat in which the species were found supports this conclusion. This habitat also extends outside the direct and indirect impact areas and is likely to be able to support the species elsewhere (Engenium, 2015 – Appendix 10.8).

Buddelundia '46' was recorded from a single location within the low halophytic shrubland. This species is known from a single specimen collected inside the direct impact area, but 100 m from planned infrastructure locations (Engenium, 2015 – Appendix 10.8). During operation, the location of this species would be flagged and any construction activity in this area would be avoided. The habitat in which the species was collected extends further than the direct and indirect impact areas.

Spherillo sp. indet. is a slater species recorded from two habitats. Similar specimens which may represent the same species have been recorded in the region from Yakabindie to Yeelirrie. However, there is taxonomic uncertainty and further genetic analysis is required. Although recorded within the direct impact zone, the species was found outside planned construction areas and can be avoided during operation (Engenium, 2015 – Appendix 10.8). The habitats in which the species was found extend beyond both the direct and indirect impact areas.

Aname 'MYG' is a mygalomorph spider that was recorded from a single location (Engenium, 2015 – Appendix 10.8). The species was recorded in an area marked for construction. As Toro has allowed sufficient space inside the development envelope to relocate infrastructure, the location of this species can be avoided. Further SRE surveys will be undertaken prior to construction to assess whether more specimens of this species are present elsewhere.

10.7 Potential Impacts

10.7.1 Mitigation Hierarchy

The mitigation hierarchy has been considered throughout the development of the Proposal. Table 10.18 summarises how the hierarchy has been used to ensure impacts are managed appropriately.

Table 10.18: Mitigation hierarchy for fauna management

Potential Impact	Mitigation Approach	Details
Land clearing removing habitat and breeding grounds	Minimise/rehabilitate	Land clearing cannot be avoided in implementation of the Proposal. However, infrastructure would be located as far as possible in previous areas of disturbance and away from critical habitats.
Loss of vegetation and habitat due to groundwater drawdown	Minimise/reduce	As dewatering is required to allow mining operations there is the potential for excess dewatering to lead to vegetation impact if not monitored. Toro plans to install water barriers around mine pits and would monitor abstraction from the borefields. The groundwater drawdown management plan would be used to ensure that excessive drawdown does not occur.
Impacts to SRE species	Avoid	Construction in areas where SREs have been found would be relocated to prevent the loss of individuals or species.

10.7.2 Potential Impacts

Land disturbance and vegetation clearance would be an unavoidable consequence of implementing the Proposal. Planning for a total area of land disturbance of 1581.8 ha, Toro has sought to limit infrastructure development outside the mining areas. Clearance activities would be progressive, allowing many fauna species to disperse to other areas.

Based on current scientific knowledge, three invertebrate species have been identified as putative SRE species from within the Proposal area. Although one of them, *Aname MYG177*, was not recorded outside the Proposal area, it was recorded from a habitat that is widespread beyond the Proposal area. The remaining two species were recorded outside the Proposal area.

There is no permanent water source currently in the Proposal area. The Proposal, if approved and implemented, would establish artificial saline water bodies through mine dewatering and storage of water for operational purposes. Such water would be above the salinity tolerance range for water birds and the invertebrate fauna that form the basis of their diets due to extreme salinities of over 100,000 mg/L TDS (Bamford *et al.,* 2008). There are existing water bodies in the vicinity of the Proposal that already support aquatic fauna and would continue to provide a more important source for water birds.

As introduced fauna species have been in the Proposal area for a considerable time, including rabbits, cattle, sheep and predatory species, the Proposal would not add to the impacts already being caused by introduced species.

The impacts of radiation on fauna were considered as part of an ERICA assessment. The assessment found that no species were at a risk of adverse impact. An ERICA assessment takes into account a series of reference organisms, both inside and outside of the food chain (refer to Section 14.7.6 of the PER).

The direct impact area of the haul road is relatively small. Due to the linear nature of the road, no significant impact to a specific SRE species population would occur. All SRE habitats are widespread in the region. All potential SRE species in the area would be able to successfully cross the open road while the use of culverts in the establishment of the road would further reduce the possibility of it acting as a barrier to SREs. Dust, noise, light and general disturbance associated with the use of the road would be unlikely to have a significant impact on any SRE species. (Ecologia 2015f – Appendix 10.2)

10.8 Best and Worst Case Assessment of Habitat Loss

The habitat loss associated with implementation of the Proposal represents a worst case scenario. The amount of clearing required will be reviewed during ongoing engineering and design studies to assess whether the impacts to fauna can be further reduced. By incorporating Lake Maitland into the Wiluna Uranium Project, the potential effects on fauna have been significantly reduced relative to the former owner's desire to build a stand-alone project with processing facilities at Lake Maitland. The former owner's plans would have required a further 750 ha of disturbance compared to the disturbance outlined in this Proposal for Lake Maitland.

Toro would implement a Fauna Management Plan to limit operational impacts and ensure as much fauna habitat as possible remains undisturbed.

10.9 Impact Management

Toro would adopt the following measures to manage and minimise any impacts on terrestrial fauna:

- Progressive clearance of vegetation to allow fauna to disperse to other areas;
- Retention of habitat corridors and/or linkages wherever possible to allow fauna to move between remaining habitat;
- No unauthorised clearing of vegetation;
- Retention of mature/large trees where practicable;
- Installation of fauna egress points at all open voids and ponds;
- Use of directional lighting; and
- No off-road driving except in case of emergency.

10.10 Commitment

To manage the potential impacts on terrestrial fauna, Toro would include detailed fauna management measures in its Environmental Management Plan for the Proposal. Toro would also educate all employees and contractors about their responsibilities in ensuring that fauna management and protection is demonstrated to a high standard.

10.11 Outcome

The Proposal would impact vertebrate faunal assemblages on a local scale through direct loss of fauna during land clearing, loss of habitat and indirect impacts. It would be unlikely to have a significant impact on any fauna species, including any conservation significant fauna species, due to the presence of similar habitat in close proximity to the area in which the Proposal would be implemented and in the wider region.

The Proposal would not affect representation, diversity, viability and ecological function of terrestrial fauna at the species, population and assemblage level.

10.12 Cumulative Impacts on Fauna and Fauna Habitats

Information presented in the following reports provided the basis for Toro's assessment of cumulative impacts on fauna and fauna habitats:

- Outback Ecology 2002 – Lake Way Baseline Fauna Studies[a];
- Outback Ecology 2008a – Appendix 10.21: Lake Way Baseline Terrestrial Fauna Survey;
- Outback Ecology 2009a – Appendix 10.16: Lake Maitland Baseline Terrestrial Fauna Survey;
- Outback Ecology 2011b – Appendix 10.18: Lake Maitland Infrastructure Areas Baseline Terrestrial Fauna Surveys;
- Outback Ecology 2011b – Appendix 10.18: Lake Maitland Terrestrial Fauna Habitat Assessment – Borefield, Accommodation Camp, and Access Route;
- Outback Ecology 2011c – Appendix 10.52: Wiluna Uranium Project Terrestrial Fauna Assessment;
- Ecologia 2015b – Appendix 10.4: Millipede to Lake Maitland Haul Road Fauna Assessment; and
- Engenium 2015 – Appendix 10.8: Lake Maitland Level 2 Vertebrate Fauna & Targeted Reptile Survey.

[a]Unpublished report for Wiluna Gold Mine

Fauna habitat mapping has been completed for the Lake Way and Centipede areas (Outback Ecology, 2011c - Appendix 10.52), for the Millipede to Lake Maitland haul road (Ecologia 2015b - Appendix 10.4) and for Lake Maitland (Engenium – 2015 – Appendix 10.8). Habitat mapping has not been previously completed for the haul roads linking the existing Wiluna Project areas; habitat extent within these areas was estimated based on aerial imagery.

10.12.1 Fauna Habitats

A total of 11 broad-scale fauna habitat types have been identified across the study area for the purposes of this assessment. Each of these habitat types are described in more detail below. The habitat types have been synthesised from aerial photography and existing habitat mapping of the study area, as outlined above; the corresponding habitat types as listed in previous reports are also included within the descriptions below. Area calculations for habitats are shown in Table 10.19 and mapped on Figure 10.12 to Figure 10.14.

Table 10.19: Fauna habitat impact (ha)

Land system	Extension to the Wiluna Uranium Project									Wiluna Uranium Project	Cumulative Project	Mapped extent
	Extent within development envelope				Extent within disturbance footprint							
	Millipede	Haul Road	Lake Maitland	Lake Maitland Borefield	Millipede	Haul Road	Lake Maitland	Lake Maitland Borefield	Total			
Bare salt lake	1.1	-	-	-	0.3	-	-	-	0.3	131.6	131.9	718.4
Kopi dune	-	-	78.7	-	-	-	12.1	-	12.1	-	12.1	91.8
Low halophytic shrubland	185.4	4.5	1,727.9	0.2	143.9	3.6	625.6	0.2	773.3	667.5	1,440.9	3,705.1
Mallee/mulga woodland over spinifex sandplain	351.8	113.3	168.2	2.2	264.0	90.8	40.5	2.2	397.6	229.0	626.6	2,545.7
Mulga over sandplain	-	82.7	-	9.9	-	66.3	-	9.9	76.2	216.4	292.6	1,502.4
Mulga over stony ground	173.1	68.8	-	-	108.2	55.2	-	-	163.4	49.7	213.1	912.7
Open plain	-	-	584.5	0.4	-	-	66.-	0.4	66.4	43.1	109.5	919.6
Spinifex sand dune	-	-	93.1	0.3	-	-	9.6	0.3	9.9	35.3	45.2	497.2
Spinifex sandplain	-	-	13.4	9.0	-	-	1.6	9.0	10.6	-	10.5	172.8
Stony hills and footslopes	-	10.9	-	-	-	8.7	-	-	8.7	-	8.7	79.4
Woodland/shrubland over calcrete	27.5	24.0	158.2	1.5	21.4	19.3	21.0	1.5	63.1	96.9	160.0	2,022.8
Unmapped	-	-	-	-	-	-	-	-	-	60.6	60.6	-
Total	**739.0**	**304.2**	**2,824.0**	**23.6**	**537.9**	**243.9**	**776.4**	**23.6**	**1,581.7**	**1,530.0**	**3,111.7**	**-**

Figure 10.12: Fauna habitats and significant fauna - Map 1

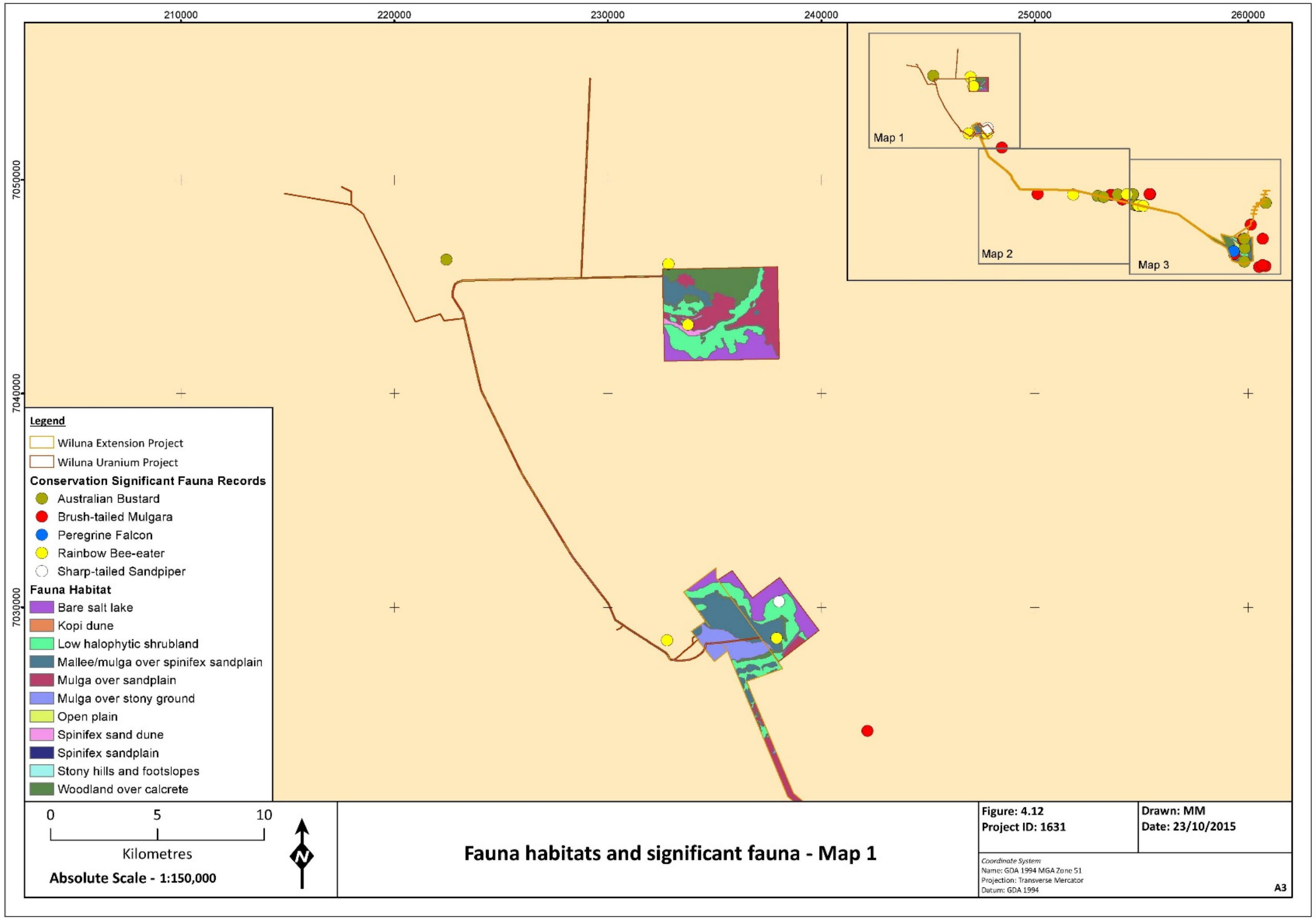


Figure 10.13: Fauna habitats and significant fauna - Map 2

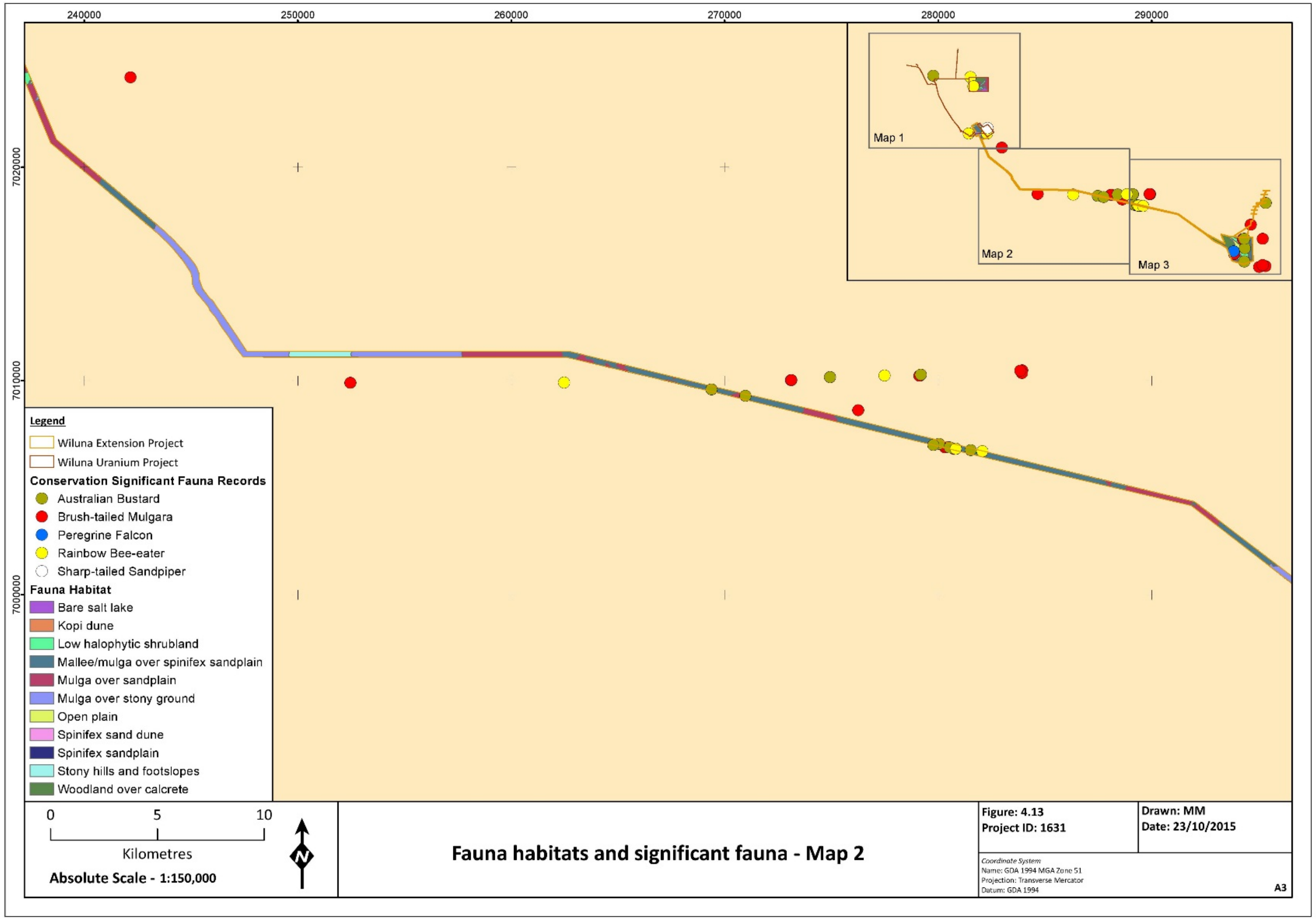
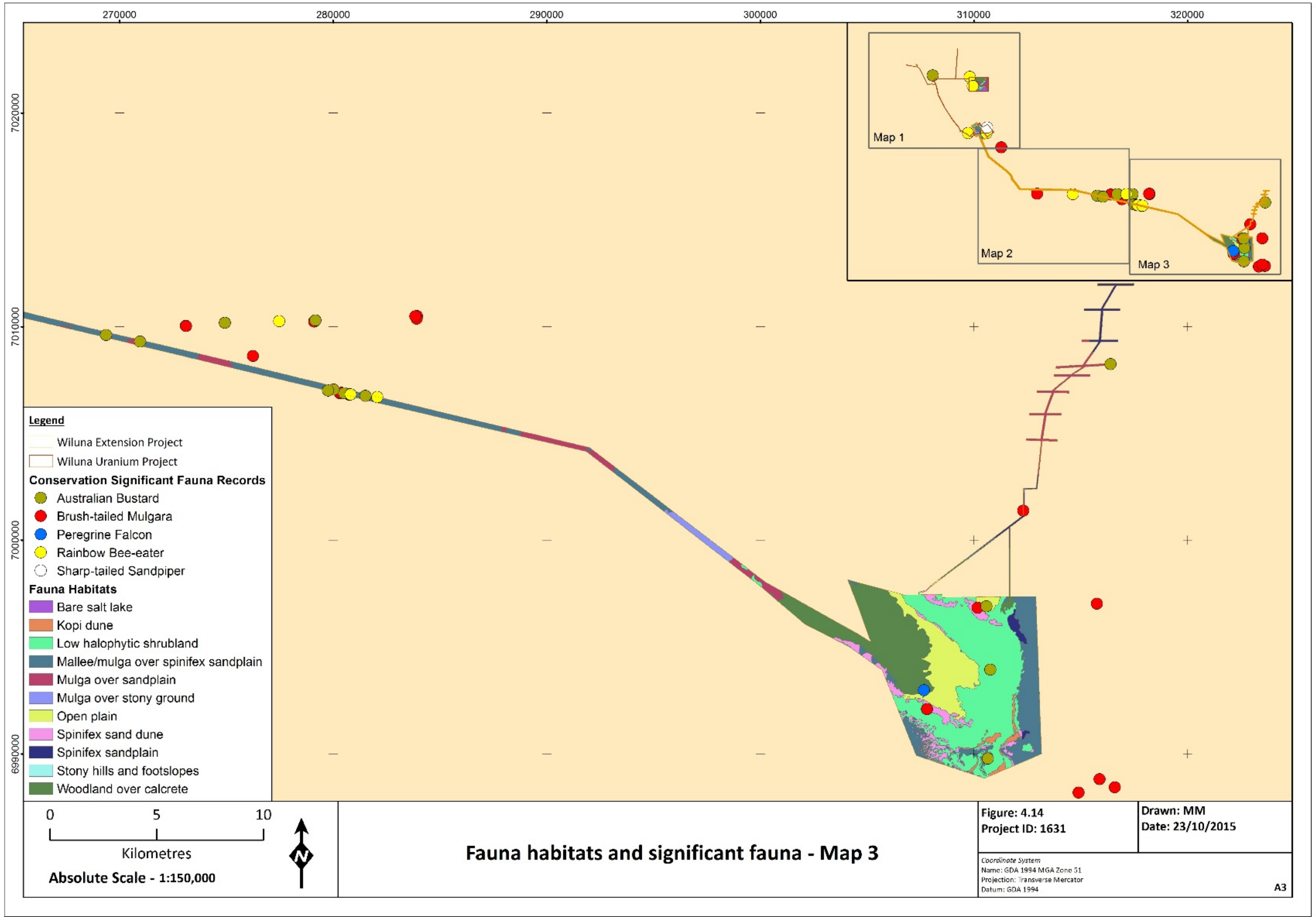


Figure 10.14: Fauna habitats and significant fauna - Map 3



Low Halophytic Shrubland

The low halophytic shrubland habitat type is the most extensive by area across the study area, occupying over 3700 ha. It is characterised by low, moderately open shrubland of chenopods such as *Maireana* and *Tecticornia* on clay flats, interspersed in some areas by low sandy dunes with an open cover of *Lawrencia* shrubland. This habitat type occurs primarily in association with Lake Way and Lake Maitland, or smaller claypan areas.

After rainfall, some areas within this habitat type flood, creating wetland habitat suitable for migratory-listed waders including the Sharp-tailed Sandpiper. It also provides potentially suitable foraging habitat for Grey and Peregrine Falcons, and the Australian Bustard.

The low halophytic shrubland habitat type encompasses the following previously-mapped habitat types:

- Low halophytic shrubland (Ecologia, 2015b - Appendix 10.4; Engenium 2015 - Appendix 10.8);
- Claypan; chenopod floodplain; samphire flats (Outback Ecology 2011c - Appendix 10.52); and
- Samphire flat (Outback Ecology 2012d - Appendix 10.65).

Figure 10.15: Low halophytic shrubland habitat type

Mallee/Mulga Over Spinifex Sandplain

The mallee/mulga over spinifex sandplain habitat type occurs widely across the study area, and is the second most extensive habitat type by area. It is characterised by open mixed woodland of mallee (*Eucalyptus* sp.) and mulga (*Acacia aneura*), over an open mid-storey of *Acacia* shrubs and ground cover of open spinifex (*Triodia basedowii*) on an orange sandy clay substrate. Leaf and wood litter is abundant at the base of mallees, but sparse elsewhere (Ecologia 2015c - Appendix 10.5).

The sandy substrate within this habitat type is suitable for burrowing by Brush-tailed Mulgara and Rainbow Bee-eater, while it provides suitable foraging habitat for Grey and Peregrine Falcons, and Australian Bustard.

The mallee/mulga over spinifex sandplain habitat type encompasses the following previously-mapped habitat types:

- Mallee/mulga woodland over spinifex plain (Engenium 2015 - Appendix 10.8);
- Mallee/mulga over spinifex sandplain (Ecologia 2015b – Apendix 10.4);
- Mallee/mulga complex over spinifex Outback Ecology 2011c - Appendix 10.52); and
- Woodland over sand plain (Outback Ecology 2012d - Appendix 10.65).

Figure 10.16: Mallee/mulga woodland over spinifex plain habitat type

Woodland/Shrubland Over Calcrete

The woodland/shrubland over calcrete habitat type encompasses a variety of Eucalyptus, Acacia, Allocasuarina, and Melaleuca over an open shrub and ground cover layer an open shrub and ground cover layer including a mixture of Acacia, Melaleuca, Triodia, Eremophila, Ptilotus and Solanum. The substrate is clay or sandy clay, with varying levels of calcrete scattered throughout. Leaf-litter occurs under trees and shrubs, while wood-litter is moderate (Outback Ecology 2011b - Appendix 10.18; Engenium 2015 - Appendix 10.8).

This habitat type provides potential breeding habitat for Grey and Peregrine Falcons in areas where taller trees are present, as well as suitable habitat for Australian Bustard, and foraging habitat for Rainbow Bee-eater.

The woodland/shrubland over calcrete habitat type encompasses the following previously-mapped habitat types:

- Woodland on calcrete plain (Engenium 2015 - Appendix 10.8);
- *Melaleuca* over calcrete flats (Ecologia 2015b - Appendix 10.4);
- *Melaleuca* stands; *Acacia victoriae* shrubland over calcrete; eucalypt woodland (Outback Ecology 2011c - Appendix 10.52); and
- Woodland over calcrete plain (Outback Ecology 2012d - Appendix 10.65).

Figure 10.17: Woodland/shrubland over calcrete habitat type

Mulga Over Sandplain

The mulga over sandplain habitat type occurs widely over the Project area, and is characterised by open mulga (*Acacia aneura* complex) woodland over sparse shrubland, with a scattered ground covering of *Triodia* sp., chenopods and tussock grasses on sandy loam or sandy clay. Leaf litter is present under trees and shrubs, while wood litter is mostly sparse (Outback Ecology 2011b - Appendix 10.18; Ecologia 2015b - Appendix 10.4).

The mulga over sandplain habitat type provides suitable foraging habitat for Peregrine and Grey Falcon, Australian Bustard, Rainbow Bee-eater and Brush-tailed Mulgara.

The mulga over sandplain habitat type encompasses the following previously-mapped habitat types:

- Mulga woodland (Engenium 2015 - Appendix 10.8);
- Mulga over spinifex sandplain (Ecologia 2015b - Appendix 10.4); and
- Open mulga woodland over spinifex on hardpan, open mulga woodland over spinifex, mulga woodland over chenopod shrubland Outback Ecology 2011c - Appendix 10.52).

Figure 10.18: Mulga over sandplain habitat type

Open Plain

The open plain habitat type occurs primarily within the Lake Maitland study area, and is characterised by flat plains of orange clay interspersed with calcrete. The habitat is very open, with a very low ground cover of native grasses and some chenopods, with sparse shrubs and low trees occurring as lone plants or occasionally in small, isolated stands. Leaf and wood litter is sparse and restricted to the base of trees and shrubs (Engenium 2015 - Appendix 10.8).

The open plain habitat type provides suitable breeding habitat for the Australian Bustard, and suitable foraging habitat for Peregrine and Grey Falcon, and Rainbow Bee-eater.

The open plain habit type encompasses the following previously-mapped habitat types:

- Open calcrete plain (Engenium 2015 - Appendix 10.8); and
- Calcrete plain (Outback Ecology 2012d - Appendix 10.65).

Figure 10.19: Open plain habitat type

Mulga Over Stony Plain

The mulga over stony ground habitat type occurs widely across the study area, and is characterised by sparse *Acacia aneura*-complex woodland over open shrubland of *Eremophila* sp., and *Acacia* sp., with open *Aristida contorta, Enneapogon caerulescens, Eragrostis eriopoda, Monachather paradoxus* and *Eriachne* sp. tussock grassland. The soil substrate consists of a firm brownish sandy-clay or clay-loam interspersed with stones or rocky ground. Leaf-litter is found only under trees and shrubs, and wood-litter is generally sparse to moderate (Outback Ecology 2011b - Appendix 10.18; Ecologia 2015b - Appendix 10.4).

The mulga over stony ground habitat type provides suitable habitat for the Australian Bustard, and suitable foraging habitat for Rainbow Bee-eater, and Peregrine and Grey Falcons.

The mulga over stony ground habitat type encompasses the following previously-mapped habitat types:

- Mulga over stony tussock grassland (Ecologia 2015b - Appendix 10.8); and
- Mulga over quartz loam, mulga over calcrete (Outback Ecology 2011c - Appendix 10.52).

Figure 10.20: Mulga over stony ground habitat type

Bare Salt Lake

The bare salt lake habitat type occurs at the Lake Way, Centipede East and Millipede study areas. It is characterised by bare ground on the Lake Way lake bed. No vegetation is present, so leaf and wood litter is also absent (Outback Ecology 2011c - Appendix 10.52).

After rainfall, some areas within this habitat type may flood, creating suitable habitat for migratory-listed waders including the Sharp-tailed Sandpiper. At such times, it also provides suitable foraging habitat for Grey and Peregrine Falcons

The bare salt lake habitat type encompasses the following previously-mapped habitat types

- Salt lake (Outback Ecology 2011c - Appendix 10.52).

Figure 10.21: Bare salt lake habitat type

Spinifex Sand Dune

The spinifex sand dune habitat type occurs around the margins of both Lake Way and Lake Maitland. It is characterised by dense hummocks of *Triodia* sp. with scattered trees and shrubs on sand or sandy clay, often on raised sand dunes. Leaf and wood litter is present but limited to under trees and shrubs (Outback Ecology 2011b - Appendix 10.18; Engenium 2015 - Appendix 10.8).

The spinifex sand dune habitat type provides suitable habitat for Brush-tailed Mulgara potential breeding habitat for the Rainbow Bee-eater, and potentially suitable foraging habitat for Grey and Peregrine Falcon, and Australian Bustard. The habitat type is also likely to be restricted in occurrence within the wider area as it is specifically associated with lake edges (Outback Ecology 2011c - Appendix 10.52). It also contains particularly old and mature stands of spinifex which form tall, extensive and continuous hummocks; such mature spinifex stands are not common within the region (Engenium 2015 - Appendix 10.8).

The spinifex sand dune habitat type encompasses the following previously-mapped habitat types:

- *Triodia* plurinervata on lake edge (Engenium 2015 - Appendix 10.8);
- Red sand dune (Outback Ecology 2011c - Appendix 10.52);
- Spinifex sand plain (Outback Ecology 2012d - Appendix 10.65); and
- Bull spinifex on lake edge (Outback Ecology 2012d - Appendix 10.65).

Figure 10.22: Spinifex sand dune habitat type

Spinifex Sand Plain

The spinifex sand plain habitat type occurs in patches to the north-east of Lake Maitland and west of Lake Way. It is characterised by moderately dense hummock grassland of *Triodia basedowii* with an open shrub layer of *Acacia* spp. and scattered mallees on clay-sand. Leaf litter is sparse, and largely restricted to the base of trees and shrubs (Engenium 2015 - Appendix 10.8).

The spinifex sandplain habitat type provides suitable habitat for the Brush-tailed Mulgara, potential breeding habitat for the Rainbow Bee-eater, and potentially suitable foraging habitat for Grey and Peregrine Falcon, and Australian Bustard.

The spinifex sandplain habitat type encompasses the following previously-mapped habitat types:

- Open spinifex sandplain (Engenium 2015 - Appendix 10.8).

Figure 10.23: Spinifex sandplain habitat type

Kopi Dune

The kopi dune habitat type occurs around the margins of Lake Maitland. It is characterised by raised ridges of gypsum supporting low open eucalypt woodland with a sparse understorey of *Grevillea*, *Lawrencia* and herbs and grasses. Beds of leaf and wood litter are present around the base of eucalypts (Engenium 2015 - Appendix 10.8).

The taller eucalypts within this habitat type may provide suitable breeding habitat for Grey or Peregrine Falcons. The kopi dune habitat type also provides suitable foraging habitat for the Rainbow Bee-eater and Australian Bustard.

The kopi dune habitat type encompasses the following previously-mapped habitat types:

- Kopi dune (Engenium 2015 - Appendix 10.8);
- Mosaic of Kopi dune and samphire flat (Outback Ecology 2012d - Appendix 10.65); and
- Kopi dune (Outback Ecology 2012d - Appendix 10.65).

Figure 10.24: Kopi dune habitat type

Stony Hills and Footslopes

The stony hills and footslopes habitat type occurs within the haul road, occupying 79.4 ha. This habitat type is characterised by sparse mulga (*Acacia aneura* complex) and *Eremophila forrestii* shrubland over open *Aristida contorta* tussock grassland on firm sandy-clay, with continuous quartz pebbles, as well as larger stones and boulders. Leaf-litter is dense under patches of *Acacia*, while wood-litter is moderate (Ecologia 2015b - Appendix 10.4).

The stony hills and footslopes habitat type is likely to provide suitable habitat for the Australian Bustard, and potentially suitable foraging habitat for Grey and Peregrine Falcons and Rainbow Bee-eater. The stony hills and footslopes habitat type encompasses the following previously-mapped habitat types:

- Stony hills and footslopes (Ecologia 2015b - Appendix 10.4).

Figure 10.25: Stony hills and footslopes habitat type

10.12.2 Significant Fauna

Five fauna species of conservation significance have been recorded within the Project disturbance envelope, within direct and indirect impact areas:

- Sharp-tailed Sandpiper (*Calidris acuminata*; EPBC Act Migratory, WC Act Schedule 3);
- Rainbow Bee-eater (*Merops ornatus*; EPBC Act Migratory, WC Act Schedule 3);
- Peregrine Falcon (*Falco peregrinus*; WC Act Schedule 4);
- Brush-tailed Mulgara (*Dasycercus blythi*; DPaW Priority 4); and
- Australian Bustard (*Ardeotis australis*; DPaW Priority 4).

Species records are shown in Figure 10.12 to Figure 10.14. All species recorded are also recorded extensively outside the study area.

10.12.3 Short-range Endemic Invertebrate Fauna

Given the ongoing development of SRE species systematics in WA, taxonomic experts (Table 10.20) have been consulted to ensure the currency of the resulting list of SRE species. Categories of SRE habitat are consistent with those identified for vertebrate fauna, which have been revised from previous assessments to unify terminology and thus enable comparison between the Wiluna Uranium Project and the Extension.

Table 10.20: Taxonomic experts

Name	Institution	Expertise
Dr Volker Framenau	Phoenix Environmental	Spiders
Dr Erich Volschenk	Scorpion ID	Scorpions
Dr Simon Judd	Phoenix Environmental	Slaters

SRE Species

A total of 21 potential and one confirmed SRE species have been recorded in the Project area. Since previous SRE sampling in 2012, 12 species have been renamed or had their SRE status changed, which reflects:

- Change in SRE categories used by Western Australian Museum (WAM) – three species;
- Loss of SRE status due to new taxonomic evidence – two species; and

- Gain and/or change in SRE status due to new taxonomic evidence – seven species.

The current status of all SRE species previously recorded is provided in Table 10.21. Of the 11 identified habitats, seven have SRE species recorded within them. Some habitats have more SRE species recorded, and in higher abundance than others (Table 10.22). For example, the habitat ‘Woodland/shrubland over calcrete’ has 10 SRE species recorded, ‘Spinifex sandplain’ has eight species and ‘Low halophytic shrubland’ has five species. Five potential SRE species have been recorded only within the Project development envelope, these species being:

- *Aname* ‘MYG227’;
- *Buddelundia* '46';
- *Lychas* ‘annulatus’;
- *Spherillo* sp. indet. (Lake Maitland 1); and
- *Urodacus* sp.

Table 10.21: Taxonomic review and current status of all previously recorded SRE species

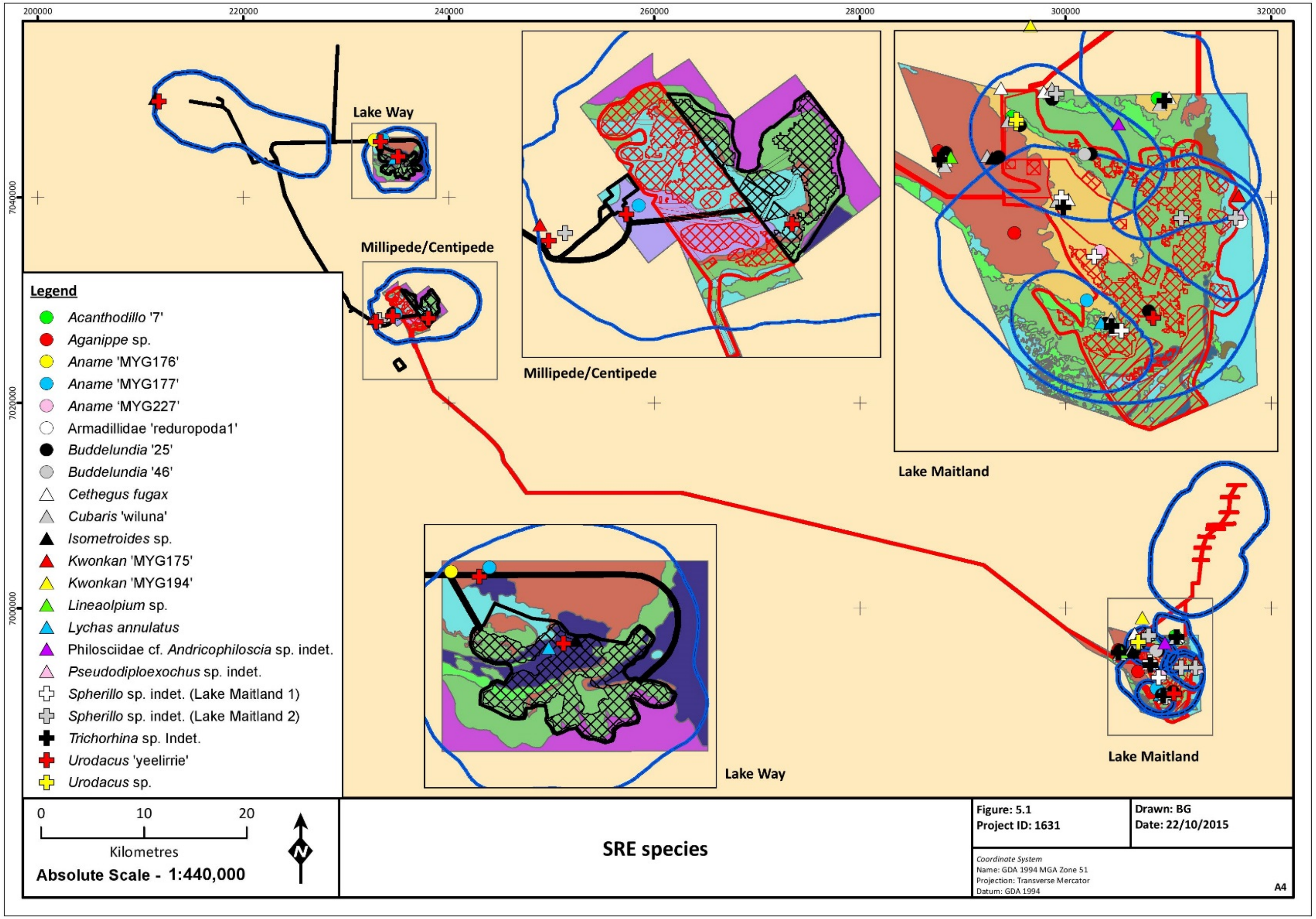
Current name	Previous name	Previous status	Current status	Comment
Arachnida – Mygalomorphae (Spiders)				
Aganippe sp.	N/A	Potential SRE	Potential SRE	N/A
Aname 'MYG176'	N/A	Potential SRE	Potential SRE	N/A
Aname 'MYG177'	N/A	Not SRE	Potential SRE	Evidence from taxonomic expert (V. Framenau, pers. comm.)
Aname 'MYG173'	N/A	Potential SRE	Not SRE	(Outback Ecology 2012 – Appendix 10.65)
Aname 'MYG227'	N/A	Potential SRE	Potential SRE	N/A
Cethegus fugax	N/A	Potential SRE	Potential SRE	N/A
Kwonkan 'MYG175'	Kwonkan sp. A	Potential SRE	Potential SRE	N/A
Kwonkan 'MYG194'	Kwonkan sp. B	Potential SRE	Potential SRE	N/A
Arachnida – Pseudoscorpiones (Pseudoscorpions)				
Linnaeolpium sp.	N/A	Potential SRE	Potential SRE	N/A
Arachnida – Scorpiones (Scorpions)				
Lychas 'annulatus'	N/A	Not SRE	Potential SRE	New genetic evidence from WAM (E. Volschenk, pers comm.)
Isometroides sp.	N/A	Potential SRE	Potential SRE	N/A
Urodacus sp.	N/A	Potential SRE	Potential SRE	N/A
Urodacus 'yeelirrie'	N/A	Potential SRE	Potential SRE	N/A
Malacostraca – Isopoda (Slaters)				
Acanthodillo '7'	*Acanthodillo* sp. 7	Likely SRE	Potential SRE	Change to WAM categories
Armadillidae 'reduropoda1'	Family Armadillidae gen. nov. sp. nov .	Likely SRE	Confirmed SRE	Evidence from taxonomic expert (S. Judd, pers. comm.)
Buddelundia '25'	*Buddelundia* cf. labiata Budde-Lund 1912	Not SRE	Potential SRE	Revised identification from taxonomic expert (S. Judd, pers. comm.)
Buddelundia '46'	*Buddelundia* sp. nov. 46	Likely SRE	Potential SRE	Change to WAM categories
Cubaris 'wiluna'	*Cubaris* sp.1	Potential SRE	Potential SRE	N/A
Philosciidae cf. *Andricophiloscia* sp. indet.	*Andricophiloscia* gen. nov.	Potential SRE	Potential SRE	N/A
Pseudodiploexochus sp. indet.	*Pseudodiploexochus* sp. Nov	Likely SRE	Potential SRE	Change to WAM categories
Spherillo sp. indet. (Lake Maitland 1)	*Spherillo* sp. 1.	Not SRE	Potential SRE	Evidence from taxonomic expert (S. Judd, pers. comm.)
Spherillo sp. indet. (Lake Maitland 2)	*Spherillo* sp.2	Potential SRE	Potential SRE	N/A
Trichorhina sp. Indet.	*Trichorhina* sp. nov.	Potential SRE	Potential SRE	N/A

Table 10.22: Habitat location records for SRE species

Current name	LHS	MSS	WSC	MS	OP	MSG	B	SD	SS	KD	SHF	No. location records
Acanthodillo '7'			●		●							3
Aganippe sp.			●						●			3
Aname ‘MYG227’					●							1
Aname ‘MYG176’			●									1
Aname ‘MYG177’			●		●	●						3
Armadillidae 'reduropoda1'				●								1
Buddelundia '25'	●		●		●				●			7
Buddelundia '46'	●											1
Cethegus fugax			●		●				●			6
Cubaris 'wiluna'			●		●				●			7
Isometroides sp.		●	●									3
Kwonkan ‘MYG175’		●										2
Kwonkan ‘MYG194’												1
Linnaeolpium sp.			●									1
Lychas ‘annulatus’				●					●			2
Philosciidae cf. Andricophiloscia sp. indet.	●											1
Pseudodiploexochus sp. indet.		●										1
Spherillo sp. indet. (Lake Maitland 1)					●				●			3
Spherillo sp. indet. (Lake Maitland 2)	●	●							●			5
Trichorhina sp. Indet.			●		●				●			4
Urodacus sp.					●							2
Urodacus 'yeelirrie'	●	●		●		●						9

Notes: LHS: Low halophytic shrubland, MSS: Mallee/mulga over spinifex sandplain; WSC: Woodland/shrubland over calcrete, MS: Mulga over sandplain, OP: Open plain, MSG: Mulga over stony ground, B: Bare salt lake, SD: Spinifex sand dune, SS: Spinifex sandplain, KP: Kopi dune, SHF: Stony hills and footslopes

Figure 10.26: SRE records



Project Development Envelope SRE Species

The five species only known within the Project development envelope are discussed below.

***Aname* 'MYG227'**

This mygalomorph spider is recorded from a single location (Site 5, Outback Ecology 2012d - Appendix 10.65) within the 'Open plain' habitat type inside the Lake Maitland development envelope (Figure 10.27). This record represents the only known specimen of this species. The total portion of this habitat proposed to be impacted by the disturbance footprint is:

- Open plain: 109.5 ha.

The habitat extends beyond the development envelope and therefore could support the species outside the development envelope

***Lychas* 'annulatus'**

This scorpion was previously not considered to be an SRE species. However, new genetic data from WAM suggests the presence of a number of separate SRE species under this name. Therefore the species within the group are now treated as potential SRE (Dr. E. Volschenk., pers.comm). *Lychas* 'annulatus' was recorded from the 'Mulga over sandplain' habitat type fringing the Wiluna Uranium Project (Site 5, Outback Ecology, 2011b - Appendix 10.18) and a single location within the 'Spinifex sandplain' (Site 4, Outback Ecology 2012d - Appendix 10.65) inside the Lake Maitland development envelope (Figure 10.28). All records of individuals are currently located within the Project development envelope. The total portion of this habitat proposed to be impacted by the disturbance footprint is:

- Mulga over sandplain: 292.6 ha; and
- Spinifex sand dune: 45.2 ha.

The habitat extends beyond the development envelope and therefore could support the species outside the Project. The two records for this species are from different areas approximately 90 km apart, indicating the species is likely to occur elsewhere in the region.

Additionally, *Lychas* 'annulatus' has been previously recorded by Ecologia across many regions of Western Australia, including Coolgardie, Murchison and Dampierland (Kimberley) bio-regions. According to current knowledge, *Lychas* 'annulatus' occurs outside the Project development envelope; however, these specimens are likely to represent different taxa with their distribution unclear.

***Urodacus* sp. Indet.**

Two specimens of *Urodacus* sp. indet. have been recorded from the 'Open plain' habitat type (Sites 3 and 7, Outback Ecology 2012d - Appendix 10.65) inside the Wiluna Extension Project development envelope (Figure 10.29). These specimens were unable to be identified to species level as they were both female and therefore lacking the morphological features required for identification. The total portion of this habitat proposed to be impacted by the disturbance footprint is:

- Open plain: 109.5 ha.

The habitat extends beyond the impact footprint and therefore could support the species outside the Project area. Although both specimen records are within the direct impact area, both records are situated where no direct infrastructure impacts are anticipated.

Additionally, as these individuals were unable to be identified to species level due to lack of morphological features, these specimens may belong to species Urodacus 'yeelirrie', which was recorded outside direct and indirect impact areas.

Buddelundia '46'

This slater is recorded only from a single location within the 'Low halophytic shrubland' (Site 8, Outback Ecology 2012d - Appendix 10.65), inside the development envelope of the Wiluna Extension Project (Figure 10.30). Currently, this single specimen record represents the only specimen known for the species (S. Judd, pers. comm.). The total portion of this habitat proposed to be impacted by the disturbance footprint is:

- Low halophytic shrubland: 1,440.9 ha.

Although the single specimen record is within the development envelope, the record is situated approximately 100 m from anticipated direct infrastructure impacts.

The habitat extends beyond the impact footprint and therefore could support the species outside the Project.

***Spherillo* sp. Indet. (Lake Maitland 1)**

This slater species was recorded from three locations (Site 8, Outback Ecology 2012d - Appendix 10.65), within the development envelope in two habitat types; 'Open plain' and 'Spinifex sand dune' (Figure 10.31). The total portion of this habitat proposed to be impacted by the disturbance footprint is:

- Open plain: 109.5 ha; and
- Spinifex sand dune: 45.2 ha.

Similar specimens which may represent the same species have been recorded in the region from Yeelirrie and Yakabindie. However, taxonomic uncertainty exists between the specimens and further detailed morphological and genetic analysis is required to be certain (S. Judd, pers. comm.).

Although specimen records are all within the development envelope, one specimen record is situated where no direct infrastructure impacts are anticipated.

Confirmed SRE Species

***Armadillidae* 'reduropoda1'**

A single confirmed SRE species, Armadillidae 'reduropoda1' was recorded during field surveys in 2011 (Outback Ecology 2012d - Appendix 10.65) (Figure 10.32). At the time of surveying, the specimen was considered a potential SRE species, but is now considered to be a confirmed SRE species (S. Judd, pers. comm.).

The species is represented by the single specimen collected for this Project, and is significant as it represents a new genus in the family Armadillidae. It was recorded within close proximity (approximately 60 m) from the Project development envelope (Figure 10.32). The specimen was recorded from mulga over sandplain habitat type. The total portion of this habitat proposed to be impacted by the disturbance footprint is:

- Mallee/mulga woodland over spinifex sandplain: 626.6 ha.

The habitat extends beyond the impact footprint and therefore could support the species away from the Project disturbance envelope.

Figure 10.27: Direct impact SRE records - *Aname* MYG227

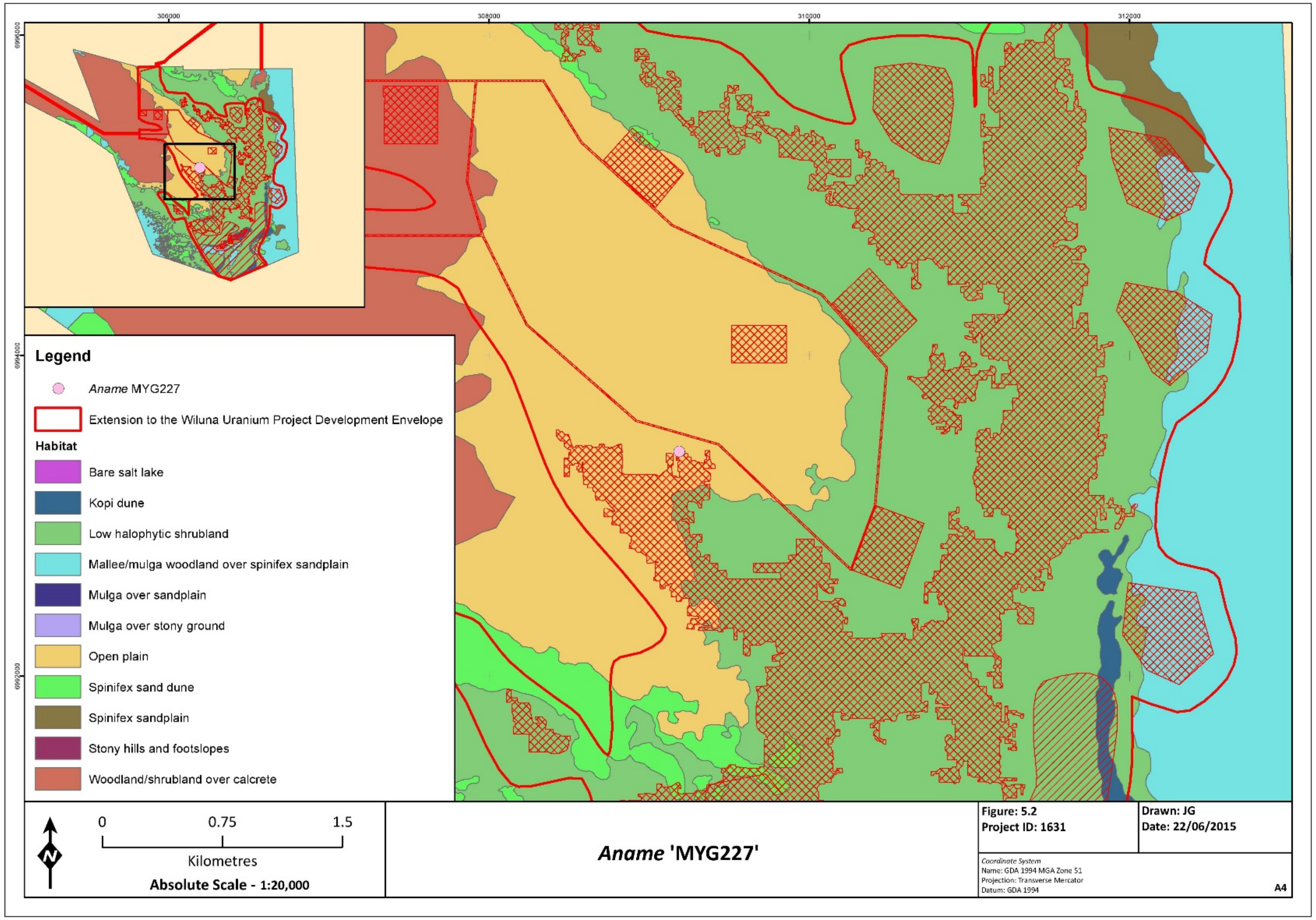


Figure 10.28: Direct impact SRE records – *Lychas* annulatus

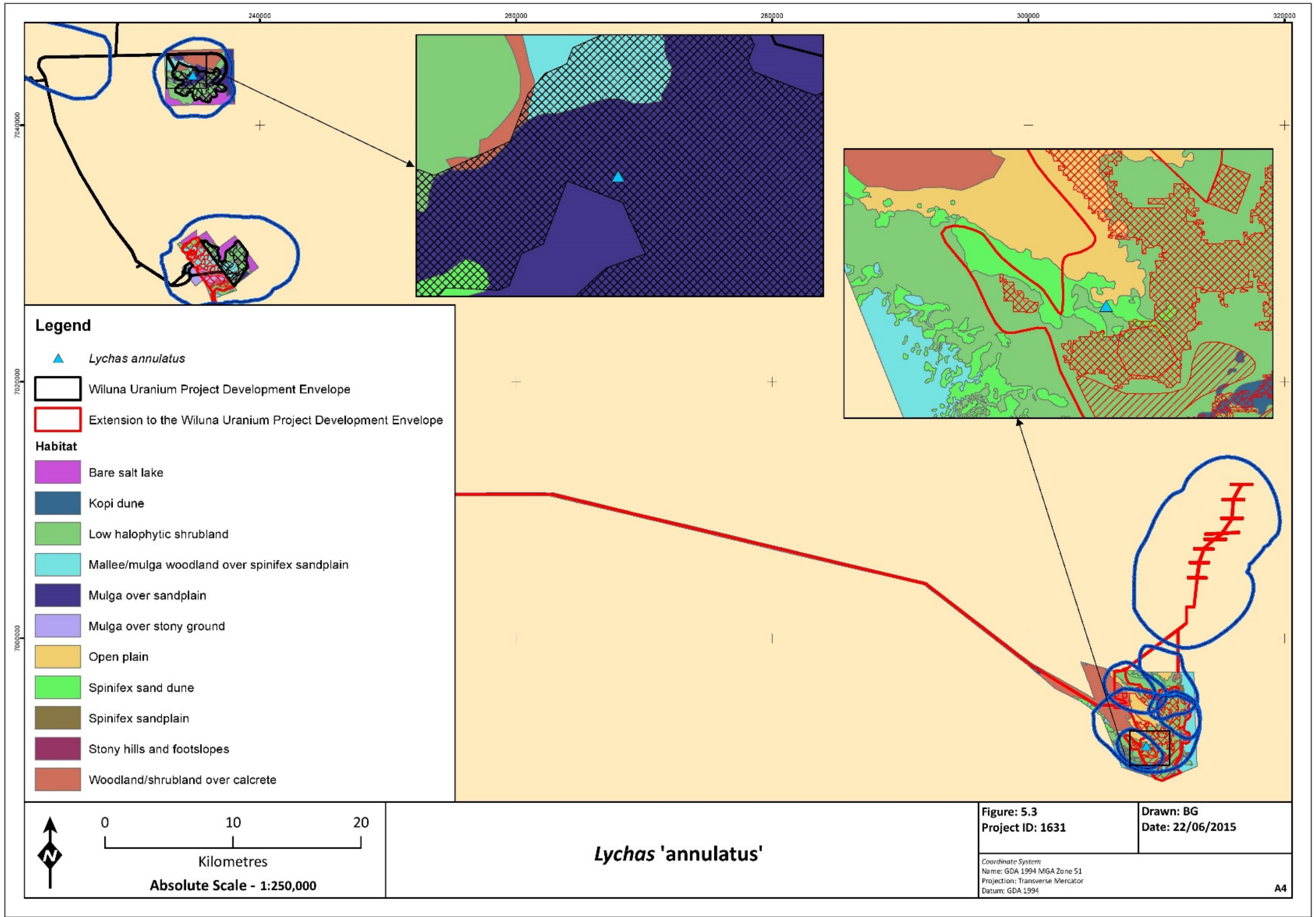


Figure 10.29: Direct impact SRE records - *Urodacus* sp.

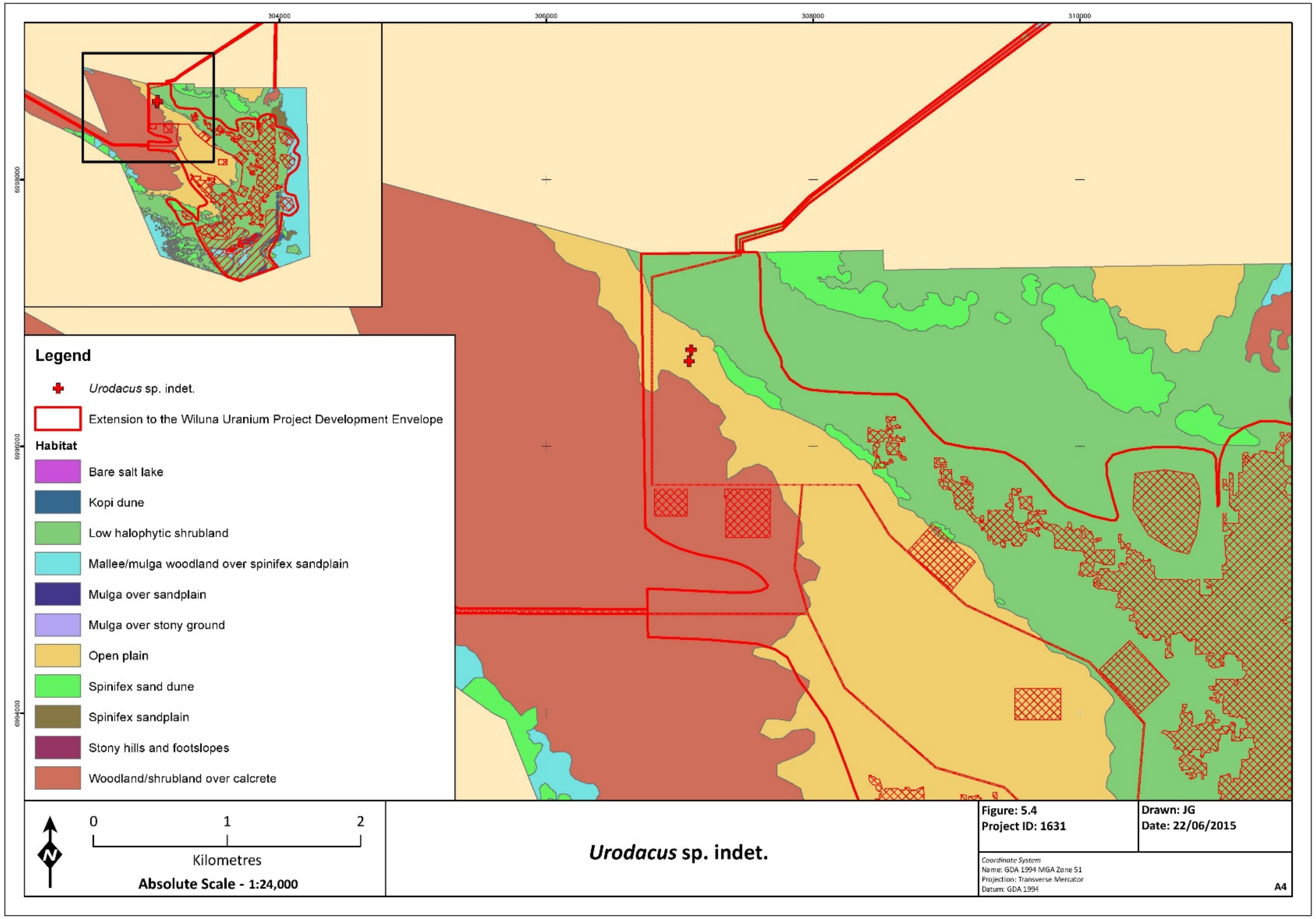


Figure 10.30: *Buddelundia* '46'

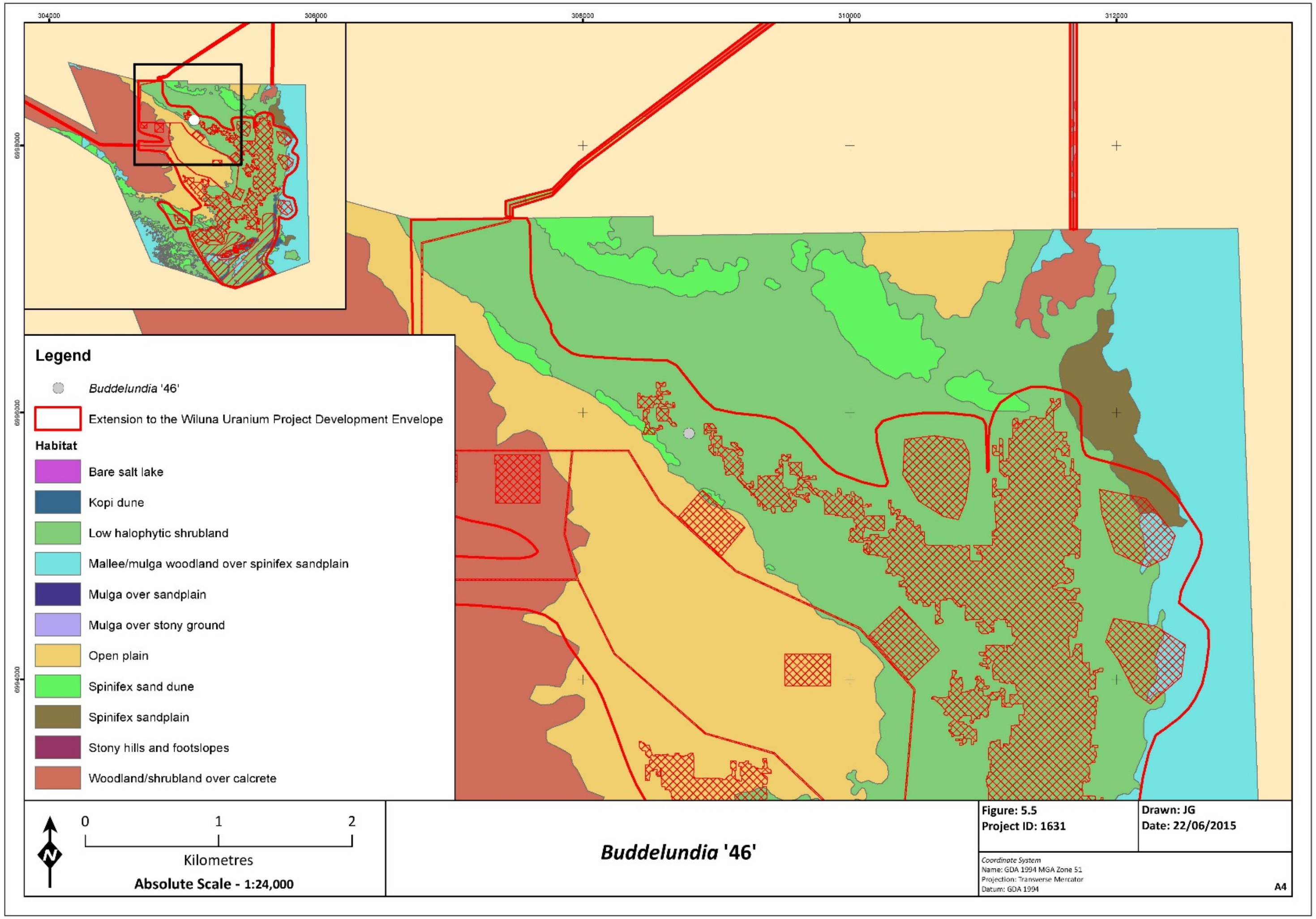


Figure 10.31: *Spherillo* sp. indet. (Lake Maitland 1)

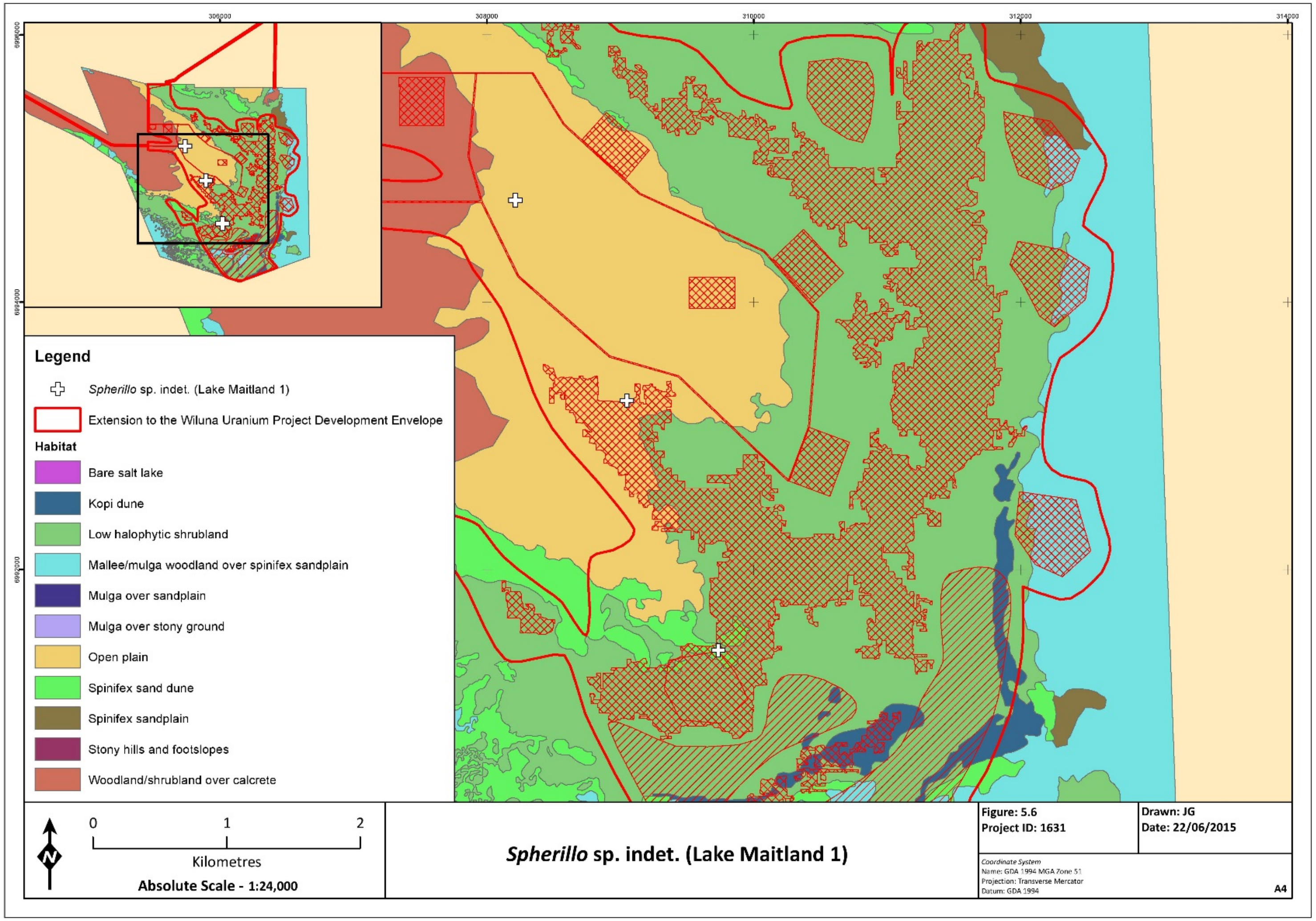
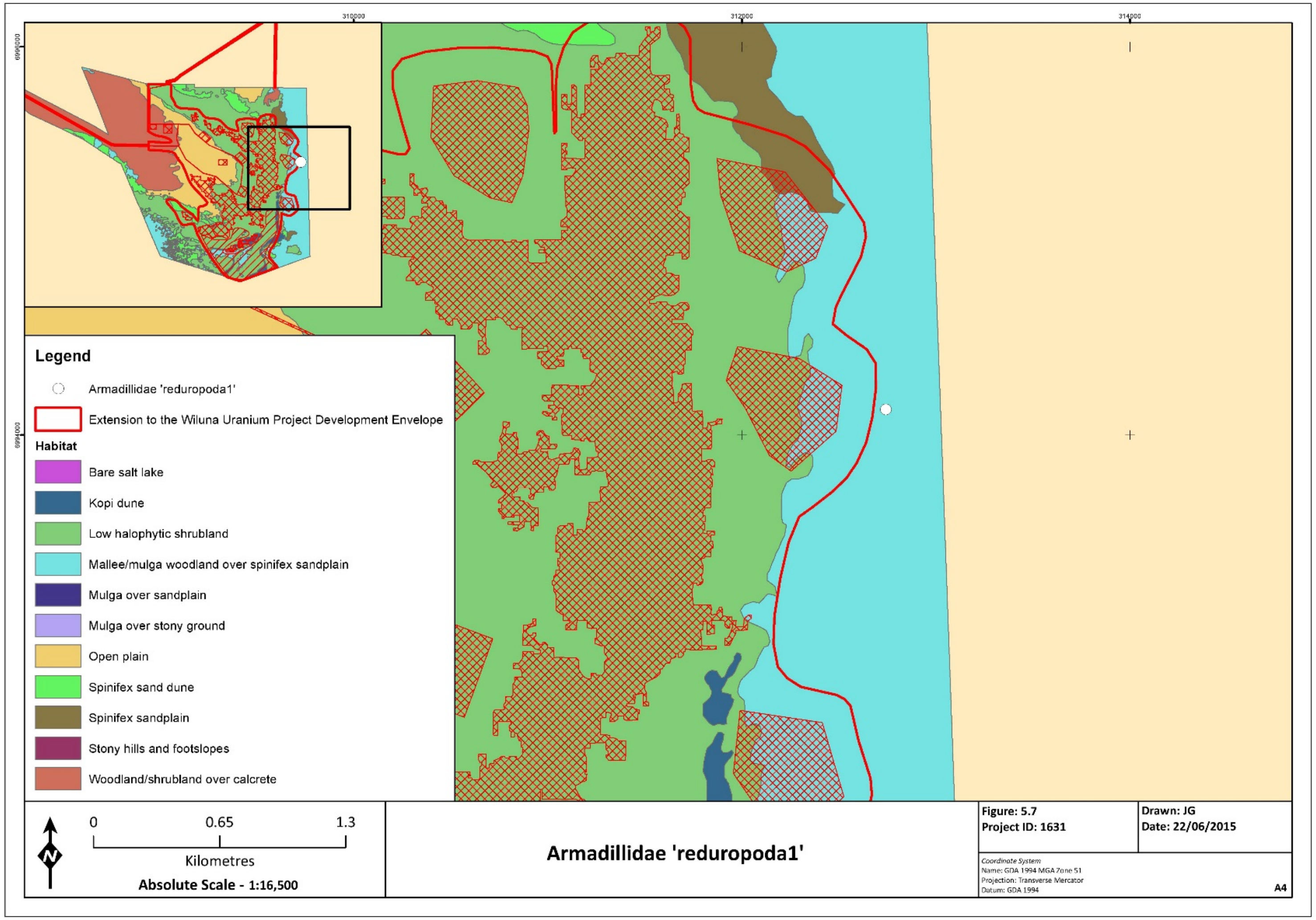


Figure 10.32: *Armadillidae* 'reduropoda1'



11 TERRESTRIAL ENVIRONMENTAL QUALITY

11.1 Objective

To maintain the quality of land and soils so that the environmental values, both ecological and social, are protected.

11.2 Relevant Legislation and Policy

The principal land degradation controls in Western Australia are provided under the *Soil and Land Conservation Act 1945* administered by the Commissioner of Soil and Land Conservation within the Department of Agriculture and Food. Under the Act, the Commissioner can serve a Soil Conservation Notice where land is being degraded or at risk of being degraded. Such a Notice can direct a person to cease activities that may cause land degradation or take measures to reduce the risk of land degradation. Local government authorities can also issue erosion notices and place restrictions on vehicle use where there is a risk of soil or vegetation degradation. The protection of native vegetation from land clearing is regulated under the EP Act and the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*.

The following legislation and guidelines are also relevant to the management of impacts on soils:

- *Mining Act 1978*;
- *Mines, Safety and Inspection Act 1994* and Regulations (1995);
- Ministerial Council on Mineral and Petroleum Resources and Minerals Council of Australia, 2003. *The Strategic Framework for Tailings Management*. Canberra, Australia;
- Department of Minerals and Energy, 2001. *Environmental Notes on Mining Waste Rock Dumps*. Western Australia;
- Water and Rivers Commission, 2001. *Mine Void Water Issues in WA*. Western Australia;
- Environment Australia, 1998. *Landform Design for Rehabilitation*. Commonwealth of Australia;
- EPA and DMP, 2015. *Guidelines for Preparing Mine Closure Plans*.
- EPA, 2006. Guidance Statement No. 6 *Rehabilitation of Terrestrial Ecosystems*; and
- EPA, 2008. Guidance Statement No. 33 *Environmental Guidance for Planning and Development*.

11.3 Proponent Studies and Investigations

11.3.1 Millipede

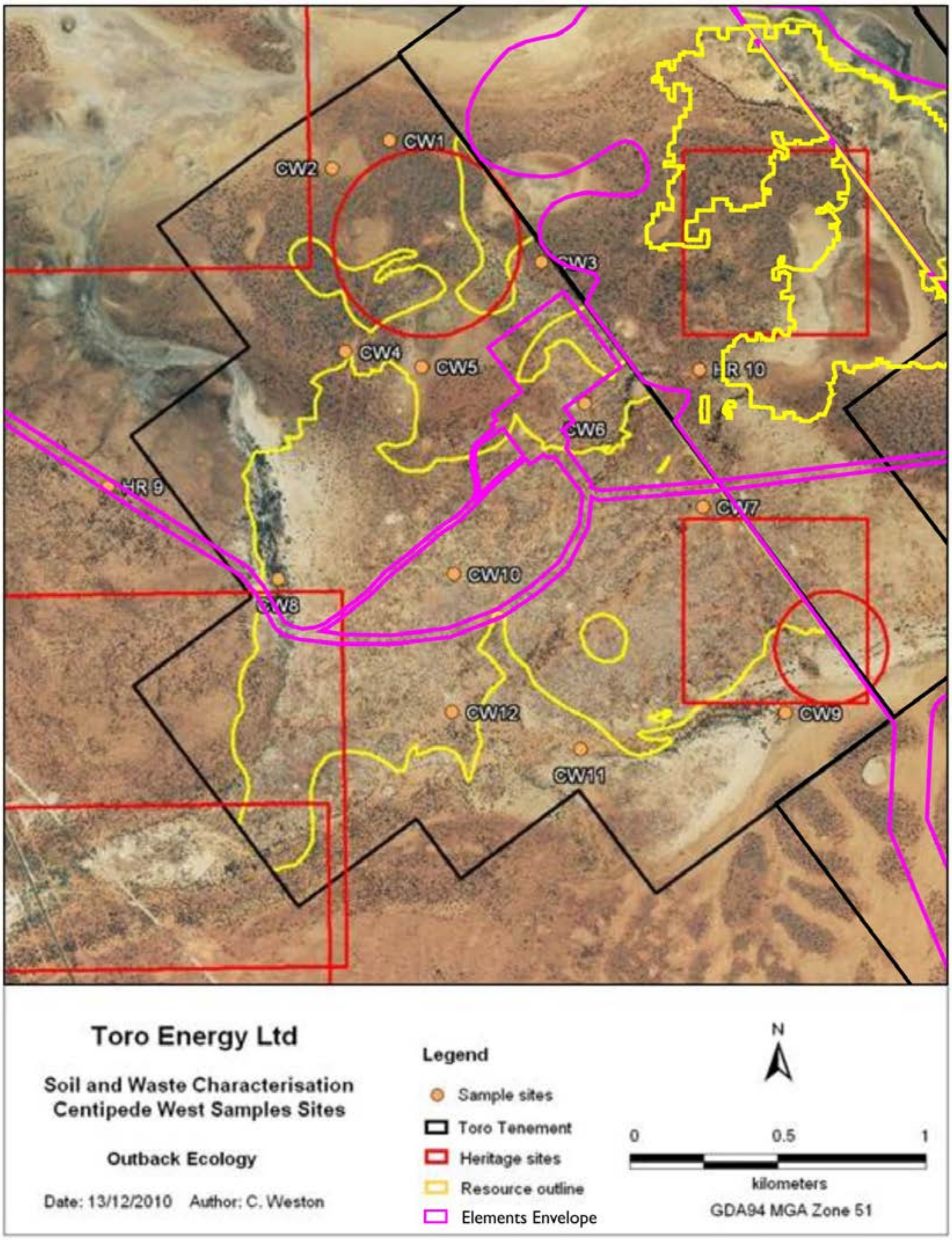
A baseline soil survey assessed surface soils to a depth of approximately 1.5 m across the Centipede and Centipede West areas. (Outback Ecology, 2010g – Appendix 10.63). A total of 11 soil sampling sites (Figure 11.1) were investigated within and close to the area of proposed disturbance for mining at Millipede.

The objectives of the baseline survey were to:

- Identify baseline levels of the chemical and physical soil characteristics present;
- Evaluate soil materials as potential rehabilitation resources within the areas of major disturbance;
- Identify potentially problematic soil/regolith materials and characteristics which may influence rehabilitation practices; and
- Identify rehabilitation strategies and offer recommendations to enhance rehabilitation of the soils identified and minimise potential impacts of problematic materials.

A desk top study of the soil along the haul road was also undertaken (Ecologia, 2015b – Appendix 10.4).

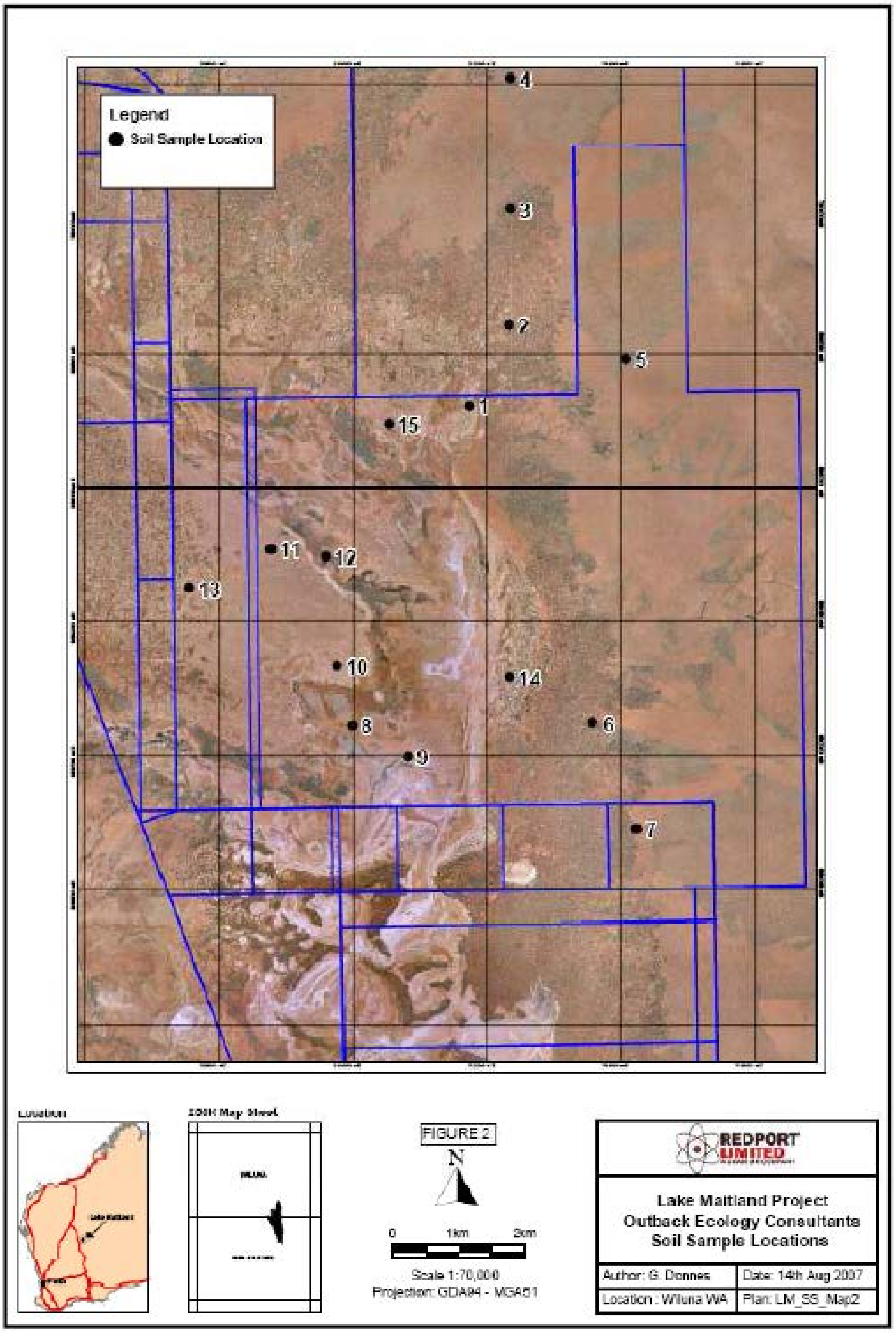
Figure 11.1: Soil sampling sites at Centipede and Centipede West



11.3.2 Lake Maitland

Soil samples were collected from a total of 15 survey sites to a maximum depth of 1 m. Based on the physical and chemical properties of the soils present, the study area was divided into four major soil management units: *Acacia* sandplains, spinifex sandplains, calcrete platforms and salt lake (Outback Ecology, 2007b – Appendix 10.15). A map of the soil sampling location is shown in Figure 11.2. Soil samples in the vicinity of the lake and the borefield have been taken. As with the Millipede soil sampling, the underlying soils control the vegetation on the surface and so can be readily mapped and extrapolated.

Figure 11.2: Soil sample locations – Lake Maitland



11.4 Existing Environment

The dominant soils of the region are red loamy earths and red-brown hardpan shallow loams, with some red shallow loams on outwash plains. Sandplains in the region have red sandy earths, red deep sands, some red loamy earths and deep yellow sands in the south-west (Tille, 2006).

11.4.1 Millipede and Haul Road

The topography comprises gently sloping sand plains, dunes and alluvial flats/playa type environments.

The Millipede deposit is located over two main land systems. The Carnegie Land System is the dominant one, encompassing the Lake Way salt lake and fringing saline alluvial plains and surrounding sand dunes. The other most common land system, the Cunya, represents the calcrete earths and platforms adjacent to Lake Way. These support halophytic shrub lands and open mulga woodlands further from the lake's edge.

A single soil unit (SV5), as classified by Bettenay *et al.* (1967) occurs across Millipede and is shown in Figure 11.3. As part of the environmental assessment of Centipede, soil investigations were undertaken across tenements to the east and west of Millipede. These studies identified five different soil types (Figure 11.4).

The soil types in the vicinity of Millipede were inferred from the Centipede and Centipede West soil investigations and were mapped based on the local vegetation and the geological information gathered by Toro over more recent drilling programs.

The majority of soils where mining would occur are loamy sands, clayey sands, sandy loams or sandy clay loams. Surface soils are generally relatively coarse in texture, but show an increase in clay content with depth. The lake bed and fringe are characterised by finer textured soils.

The soils have a relatively wide range of pH and salinity with both of these attributes related to position in the landscape. In general, soils higher in the landscape are more alkaline and less saline, while those in flat areas at lower elevation are more saline and have neutral to acidic pHs. As would be expected, soils near or on the bed of Lake Way show relatively high salinity and neutral to alkaline pHs. None of the soils show pronounced hydrophobicity (water repellence), neither do they show a tendency to hard-setting.

Baseline testing of soils for trace elements (arsenic, cadmium, copper, lead, mercury, nickel, zinc) found no evidence of enrichment in these metals. The levels of total chromium identified within many of the samples were in excess of the values conventionally identified as potentially harmful to some agricultural plant species. However, the local native plant species may show quite different tolerance to chromium in soils. There was no clear evidence of higher levels of chromium in a particular location or soil type.

On the alignment of the haul road between the processing plant location and Lake Maitland, six soils were mapped with the most widespread type the red, sandy soils of AB14 (Bettenay *et al*., 1967). All soils identified are widespread across the Murchison and all have under 0.1% of their total extent in the area studied. These are described in Table 11.1 and mapped in Figure 11.5.

Figure 11.3: Soil unit – Millipede

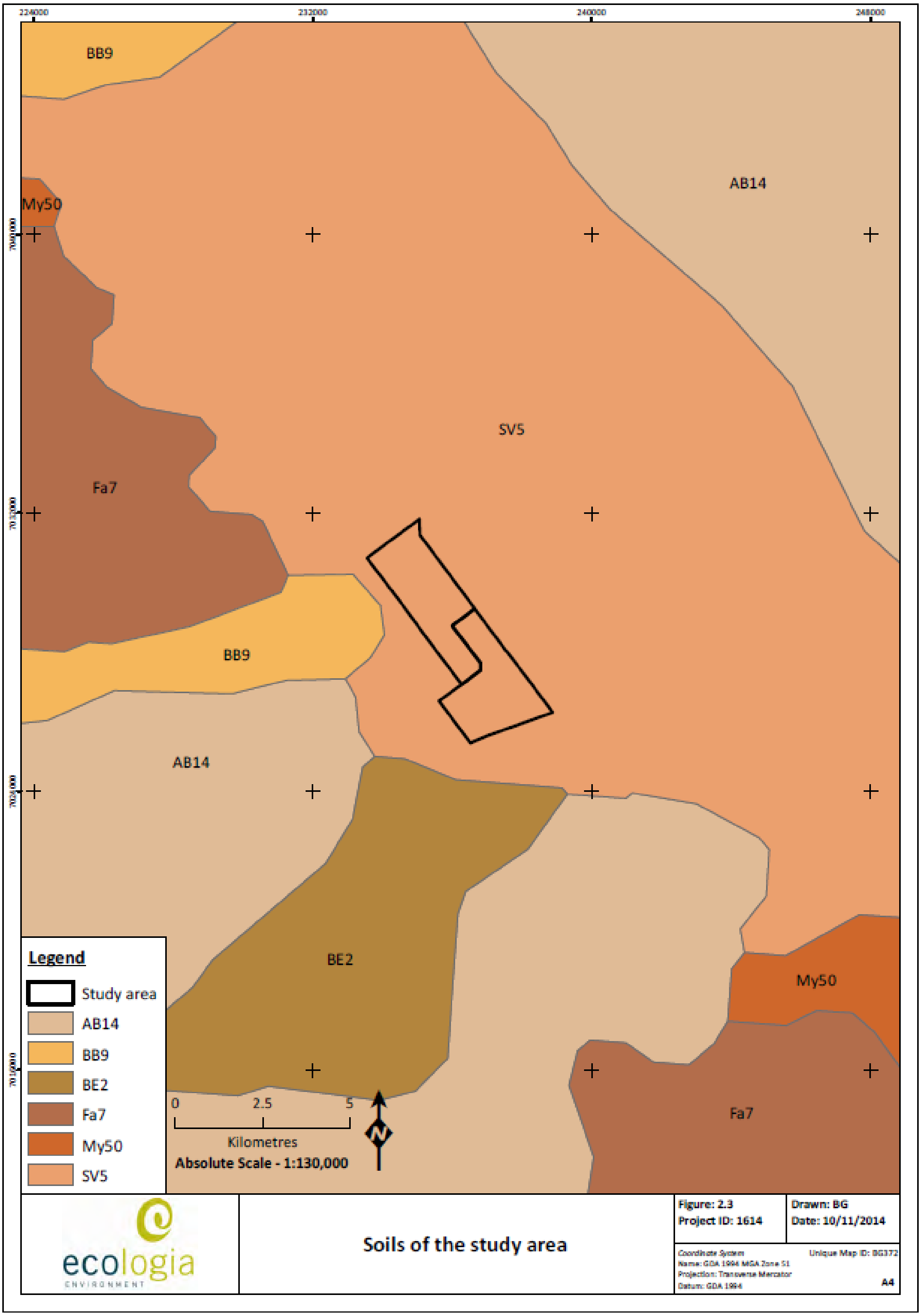


Figure 11.4: Soil types in the vicinity of Millipede

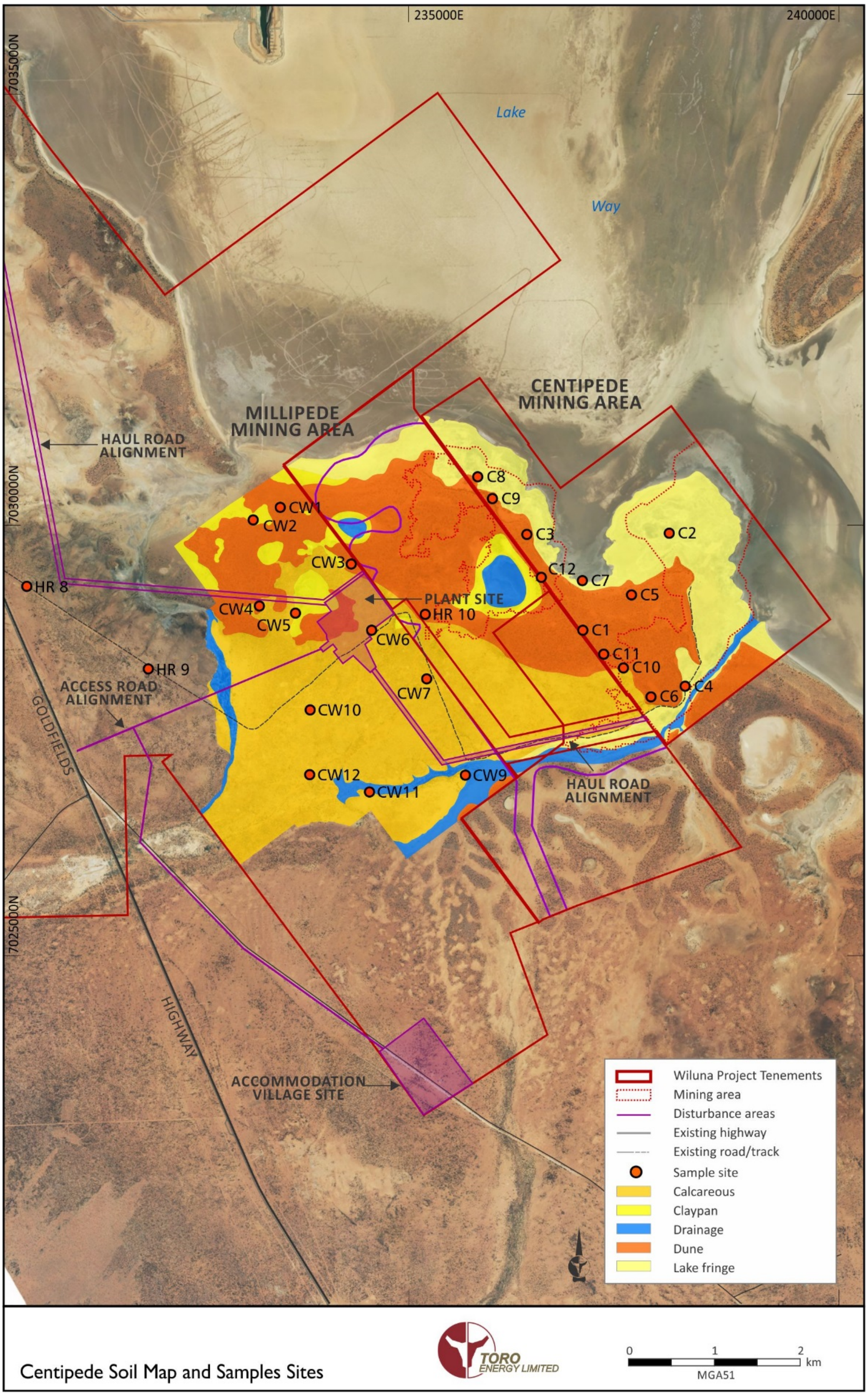
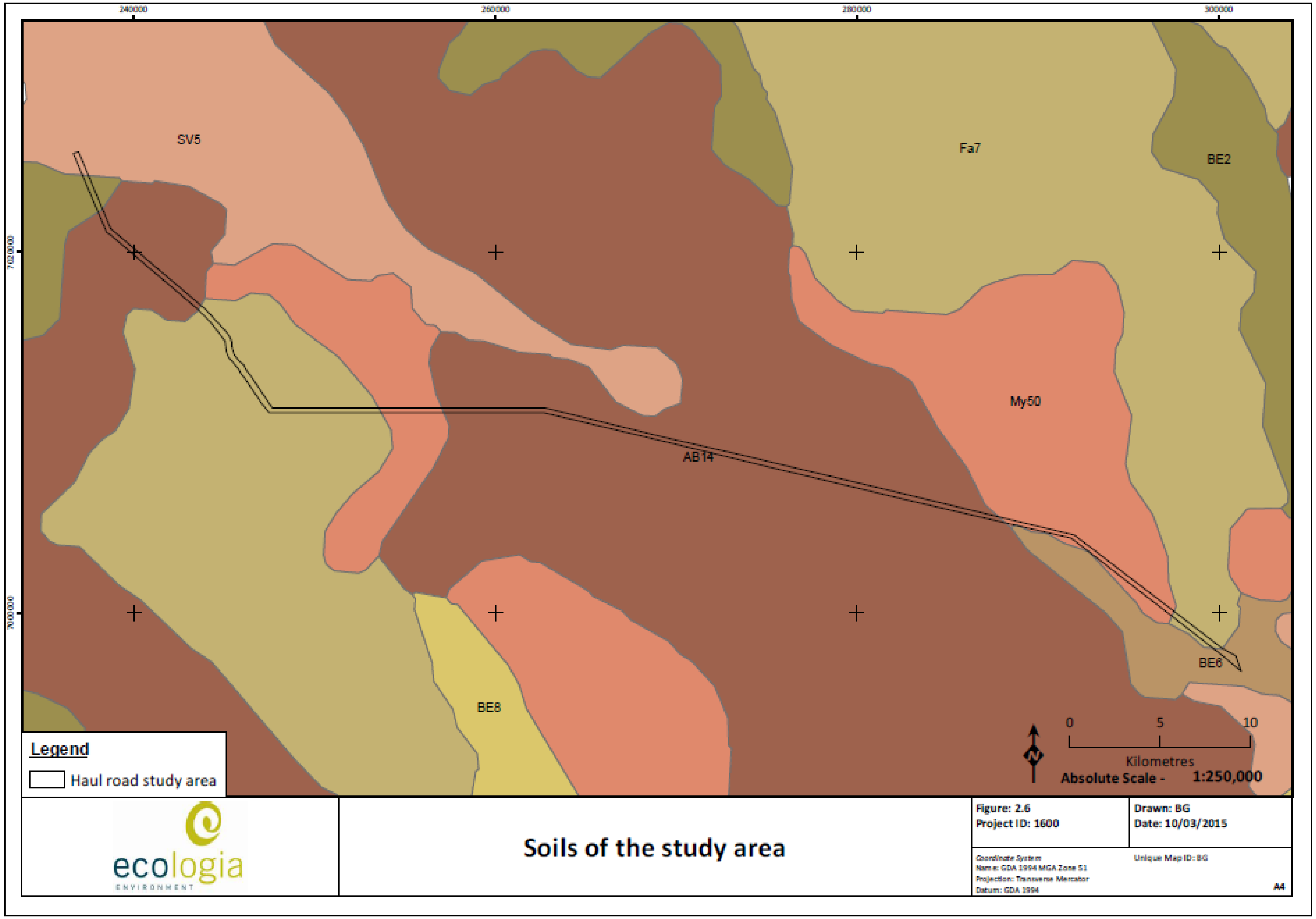


Table 11.1: Soils on the haul road alignment

Soil Code	Description	Area in Study Area (ha)	Area in Study Area Proportion (%)	Area Mapped in the Murchison (ha)	% Total Extent at the Study Area
AB14	Upland sand plains with occasional dunes and minor inclusions of associated plains units; chief soils are red.	991	40	1,722,738	0.06
BE2	Generally undulating terrain on granites with rocky granitic hills, bosses and tors, some breakaways, and a surface stone mantle; chief soils seem to be shallow earthy loams underlain by a red-brown hardpan.	64	2.6	3,521,991	0.002
BE6	Extensive flat and gently sloping plains which sometimes have a surface cover of gravels and on which red-brown hardpan frequently outcrops; chief soils are shallow earthy loams.	76	3.1	1,893,637	0.004
Fa7	Greenstone hills and low ranges with some slate and basalt; dominant soils are shallow stony earthy loams.	624	25.2	1,062,028	0.06
My50	Broad plains with a scatter of surface gravels: chief soils are shallow neutral red earths and shallow earthy loams. They are underlain by a red-brown hardpan	633	25.5	1,788,444	0.04
SV5	Saline soils associated with salt lakes; sand and kopi gypsum dunes, and intervening plains; soils are mixed, but chief soils are probably shallow, which sometimes overlie red-brown hardpan.	91	3.7	664,767	0.01

Figure 11.5: Soils on the haul road alignment



11.4.2 Lake Maitland

Locally, the typography is very flat with the ground surface of Lake Maitland (around 470 mAHD to 472 mAHD) grading from the north to south at a slope of less than 0.05% in the vicinity of the proposed mine. Regionally, the surface elevations increase to the east, west and north of the mine area at a grade of generally less than 0.2% to ground elevations along the catchment boundary of around 500 mAHD to 550 mAHD.

The landforms of the area are sand plains (with hardpan wash plains and some mesas, stony plains and salt lakes) on granitic rocks (and some greenstone) of the Yilgarn Craton.

The baseline soil survey showed a significant degree of variation in soil profile morphology, both within and between the areas sampled. The greatest variations were between soils from contrasting positions within the landscape, namely spinifex, spinifex/*Acacia*, lake playa and calcrete associations.

The four major soil management units into which the study area was divided based on their physical and chemical properties are discussed below:

11.4.3 *Acacia* Sandplains

The soil materials from the *Acacia* sandplains were generally single-grained with weak to moderate aggregates and few coarse fragments. These areas are characterised by deep red earths with a generally neutral, although variable, pH with some samples classed as very strongly acidic and some as strongly alkaline. The soils are classed as stable to very stable and non-hardsetting. The soils have low concentrations of metals and adequate amounts of plant-available nutrients for growth of local plant species. This soil management unit is relatively resilient to disturbance due to the rapid drainage and structurally stable nature of the soil materials.

11.4.4 Spinifex Sandplains

The soil materials from the spinifex sandplains have similar physical and chemical properties to the soils from the *Acacia* sandplains, except that the amount of organic carbon is lower and the soil bulk density is higher. Soil materials from the spinifex sandplains have a moderate soil structure and the profiles typically have only a small amount of coarse fragments present. The soils are classed as stable to very stable (based on the Emerson Class), are non-sodic and non-hardsetting. These soils are generally more acidic than the soils from the *Acacia* sandplains and have low concentrations of total metals and adequate amounts of plant-available nutrients.

11.4.5 Calcrete Platforms

The soil materials from the calcrete platforms have a variable amount of coarse fragments and a weak to moderate soil structure. The soils are moderately to strongly alkaline, non-sodic and non-hardsetting. Some samples indicated a propensity to disperse when subject to excessive disturbance. The materials had low levels of total metals and adequate amounts of plant-available nutrients. These soils have a moderate capacity to retain soil moisture. Due to the potentially dispersive nature of some soil samples from the calcrete platforms, care needs be taken when handling these materials, particularly when wet.

11.4.6 Salt Lake

The salt lake soils typically have relatively high amounts of organic carbon and moderate concentrations of plant-available nutrients. The soil materials are characterised as extremely saline and have very low amounts of coarse fragments, reflecting a low position in the landscape. The soil structure was classed as moderate. Their greatest limitation is their high salinity.

The results of the baseline soil survey are summarised as follows:

- A significant degree of variation in soil profile morphology exists.
- A wide range of pH and salinity values occurs across the study area—as expected, the samples from the lake playa recorded the highest salinity levels.
- There are low levels of available soil nutrients (i.e. N, P, K and S).
- Total metal concentration was below detectable limits for As, Cd, Pb, Zn and Hg, with only Cr, Cu and Ni regularly above detectable limits.
- The physical soil attributes are variable, ranging from loamy sand to light medium clay with finer-textured soils present within the lake playa.
- Soil structure is variable, with little trend attributable to position within landscape or vegetation association.
- Many soil samples exhibited dispersive properties or the tendency to disperse following severe disturbance. This indicates that these materials may be readily mobilised once disturbed and re-deposited.
- The soil-water retention characteristics are variable, reflecting differences in soil texture and particle grading.

Soil mapping across the Lake Maitland deposit identified seven different soil types (Figure 11.6). The main soil type to be disturbed by implementation of the Proposal would be the Lake Playa which sits atop the lake where the main body of the mineralisation is hosted.

11.4.7 Location of Infrastructure – Millipede and Lake Maitland

Toro has developed conceptual layouts for mining at Millipede and Lake Maitland (see Figure 6.2 and Figure 6.3). In both instances, the development envelopes have been constrained to as small as possible to ensure that a minimal footprint is achieved. Toro has located key infrastructure to ensure that any erosion that does occur is contained.

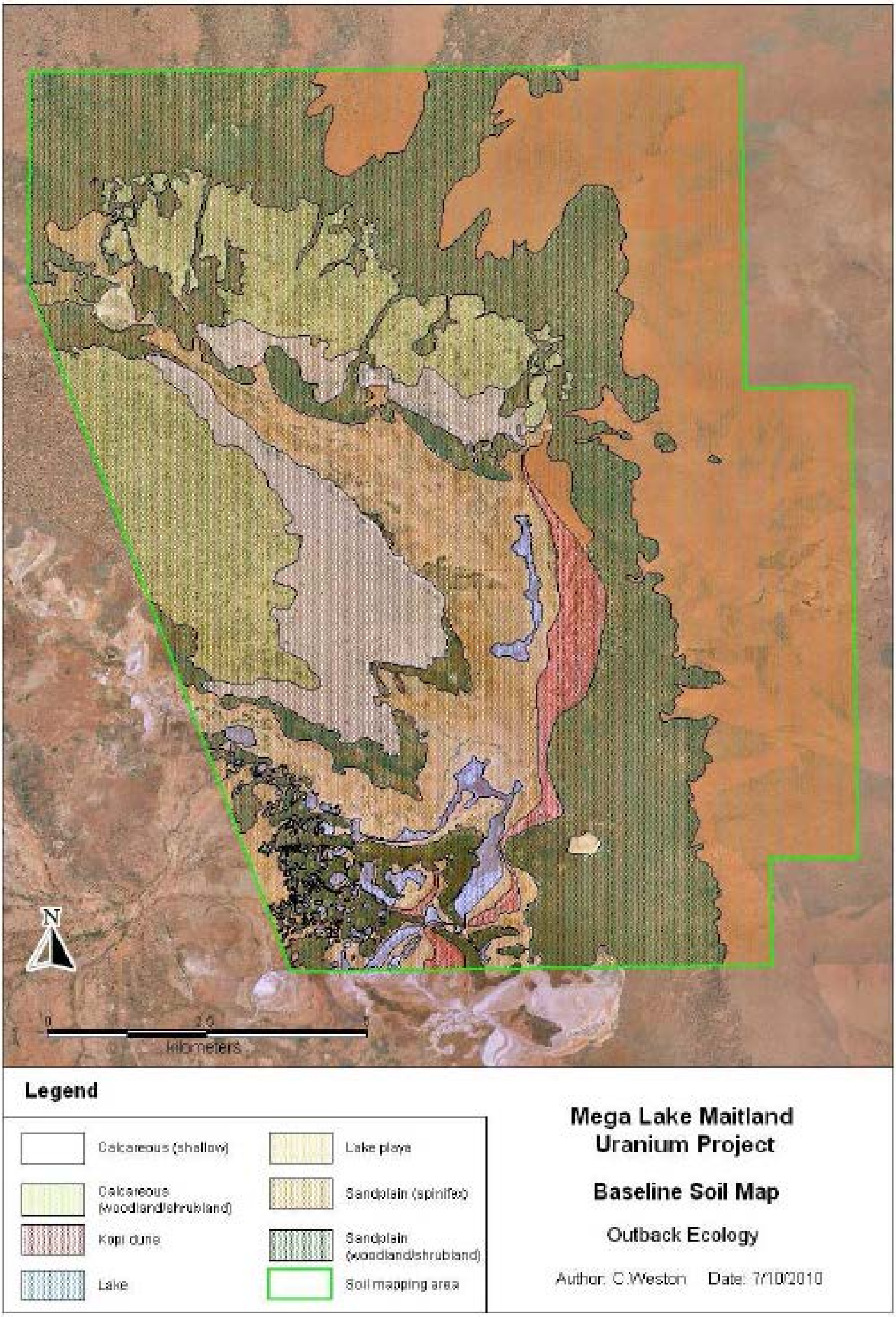
Toro aims to practise progressive rehabilitation through return of waste materials and topsoils back to rehabilitated areas where possible. All stockpiles would be removed by the end of the mine life. The conceptual mine lay-out has not allowed for the progressive rehabilitation of mining areas and so presents a worst case scenario. By practicing progressive rehabilitation, Toro would keep stockpiles to a minimum ensuring erosion and other land impacts are also minimised.

The minimisation of stockpiles would not remove the need for them. All waste stockpiles would be situated on a prepared base. All water runoff and flow through would be collected in drains and would be used either in the processing plant or for dust suppression. Stockpiles located in potential flood areas would be bunded to ensure that flood waters do not lead to additional erosion.

All stockpiles have been located outside water courses and drainage lines as much as possible. At Millipede, Abercromby Creek currently flows to the south of the deposit, immediately adjacent to mining areas. This creek would be diverted west of the mine area through another branch of the creek to separate water flows from mining operations.

Mineralised material on the ROM pad and low grade ore stockpiles would be bunded to prevent erosion and the leaching of contaminants into the surrounding environment. As the material to be recovered across the Wiluna Uranium Project would be mined in shallow oxidised deposits, mostly alkaline in nature, there is no potential for acid rock drainage issues to occur. Water from these stockpiles would be recovered and reused within the processing circuit.

Figure 11.6: Soil types at Lake Maitland



Soil characterisation studies have shown that the lake soils in particular have the potential to generate dust when allowed to dry out (Outback Ecology, 2011d – Appendix 10.22). To prevent dust generation and wind erosion, Toro would reuse runoff and flow-through water captured from the stockpiles to keep them damp. Further studies undertaken as part of the Definitive Feasibility Study will investigate other means of reducing the erosion of the stockpiles, such as physical covers and dust suppression agents.

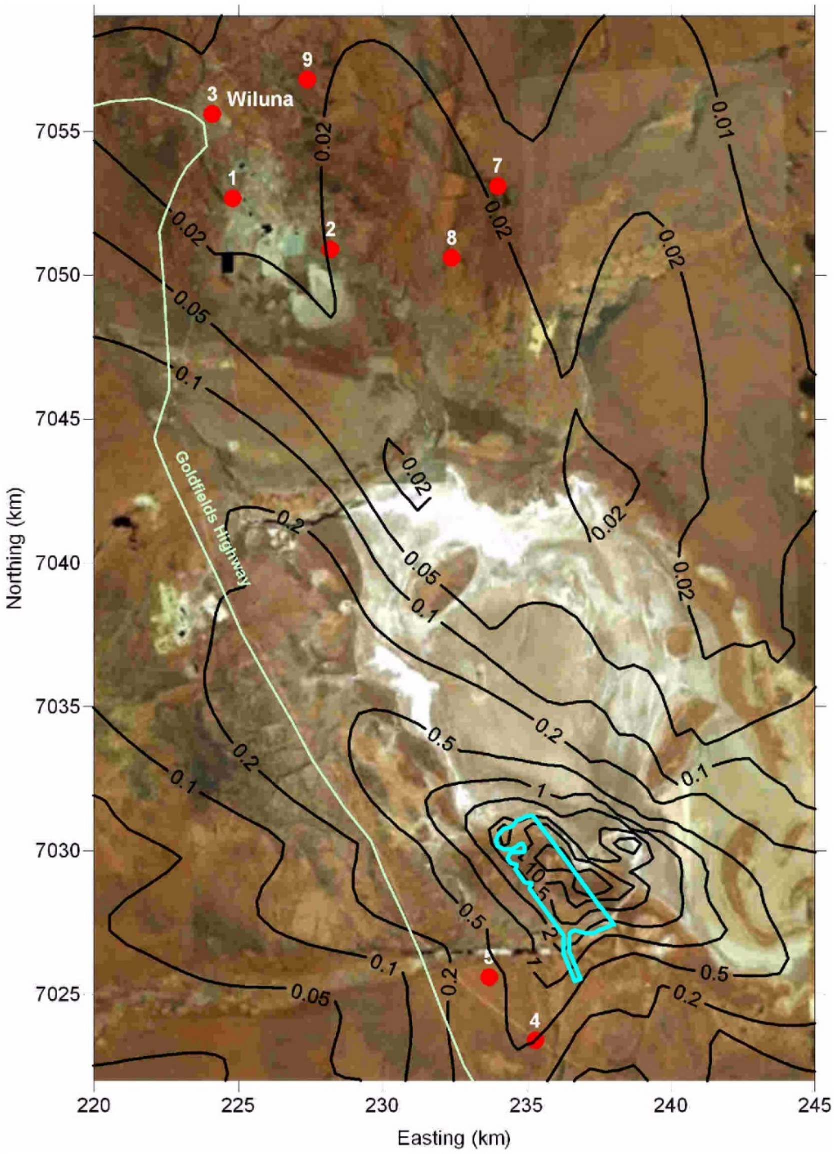
11.4.8 Dust and Radiation

Dust generation modelling has been undertaken for mining at Millipede/Centipede and at Lake Maitland. The dust deposition contours are shown in Figure 11.7 and Figure 11.8. These contours were developed using conceptual layouts and present worst case scenarios. In both cases, dust generated by the Proposal is expected to be low and monthly dust depositions at the edge of the mining leases of approximately 1 g/m^2/month are expected to occur. ERICA modelling undertaken by Toro has demonstrated that this level of dust deposition with the predicted concentration of uranium in dust would have no effect on flora and vegetation outside the mining areas (Toro Energy, 2015 – Appendix 10.34). The results of the ERICA modelling are presented in Section 14.7.6 of the PER.

Across the deposits, soil radionuclide values and local gamma radiation levels are elevated (Figure 11.9 and Figure 11.10). The highest levels of background gamma radiation correspond to the locations of the deposits. At closure, these levels would be reduced due to the removal of the uranium. Some level of radiation associated with the TSF is expected. The design of the TSF was approved following EPA Assessment 1819 and a radiation capping layer would be constructed over the top of the TSF to reduce radiation emanation. This design would be replicated at Millipede.

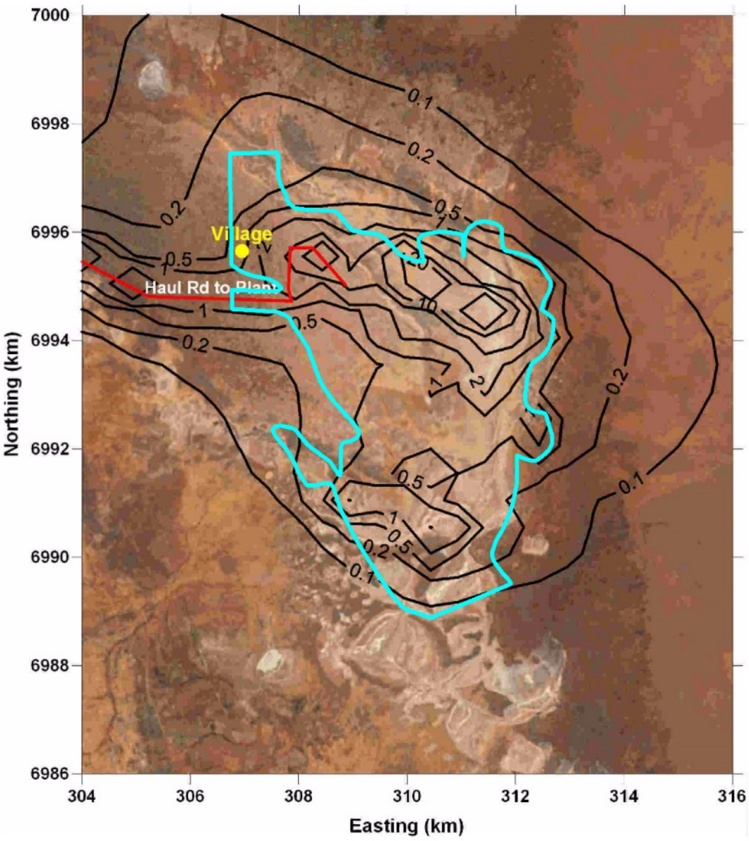
Dust emissions from the processing plant have been calculated based on the design incorporating methods to reduce emissions including keeping the ROM pad ore damp, enclosing or covering parts of the plant that have the potential to generate high levels of dust, and using negative pressures inside product drying areas and packaging areas. The Definitive Feasibility Study and Mining Proposal will incorporate measures to ensure dust generation during mining and processing is minimised.

Figure 11.7: Dust deposition (g/m²/month) – Millipede



Note: The contours show the approximate levels of additional dust deposition at the nearest sensitive receptors (red dots).

Figure 11.8: Dust deposition (g/m²/month) – Lake Maitland



Note: The contours show the approximate levels of additional dust deposition at the nearest sensitive receptors (red dots).

Figure 11.9: Map of naturally cccurring radiation at Millipede/Centipede

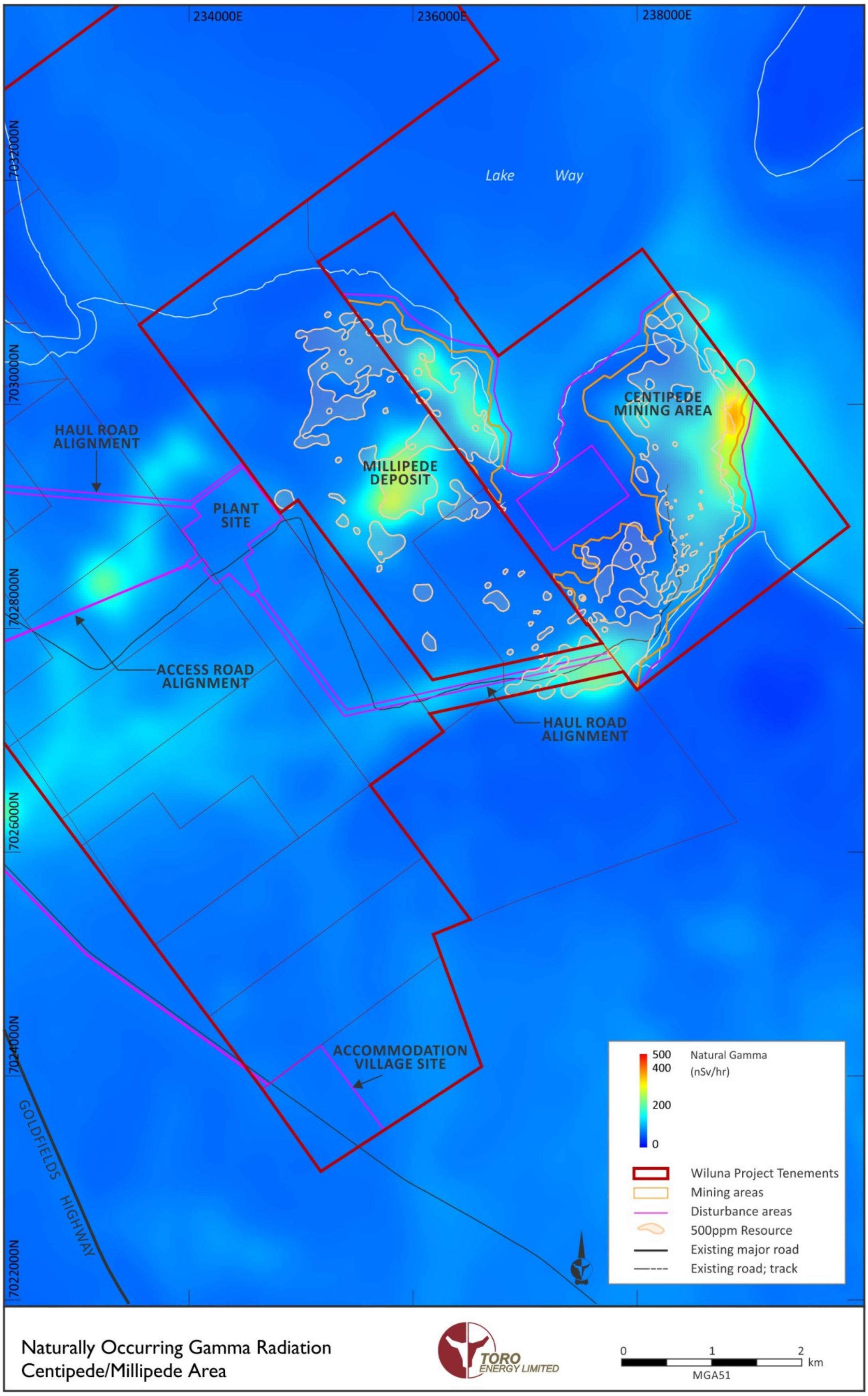
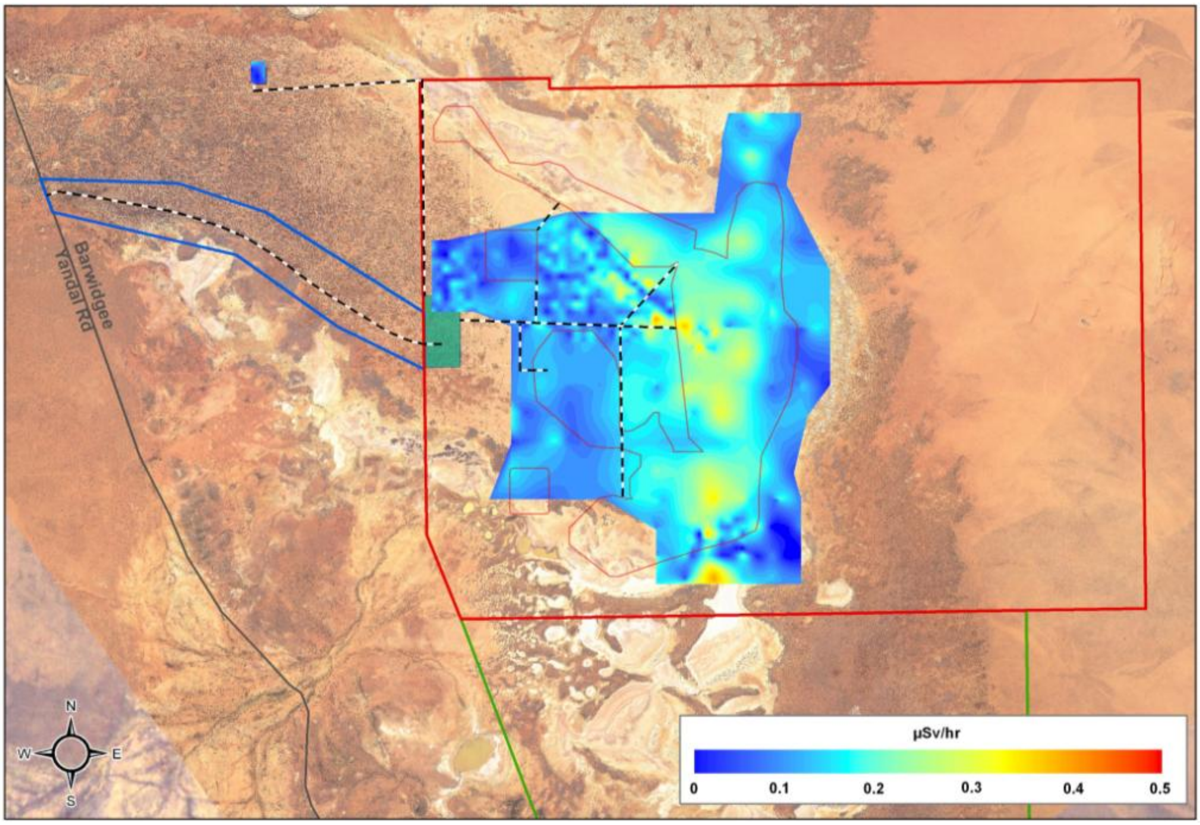


Figure 11.10: Lake Maitland baseline gamma survey



11.4.9 Waste Rock and Overburden Characterisation

Millipede

Soil and overburden characterisation was undertaken as part of EPA Assessment 1819 for Centipede. As Centipede and Millipede are continuous geological bodies separated only by administrative boundaries, the soils across them are likely to be the same.

Soil textures range from clayey to clay. Soils underlain by calcrete at shallow depth typically contain a high portion of gravel-sized rock fragments.

Soils from the lake playa and other areas of sediment deposition (claypans and the like) show some tendency towards hardsetting or the formation of crusts. This is generally not the case for soils on dunes or in the calcrete flats surrounding the lake. Soils in the Millipede and the assessed Centipede area show a wide range of permeabilities, with estimated values of saturated hydraulic conductivity spanning three orders of magnitude (from about 3 mm/h to over 300 mm/h).

The range of plant-available water (% volume) values measured in the soils is considered to be low to moderate (in the range of 15% to about 25%), which is typical of the soils of the region.

Soils across Centipede and Millipede are mainly alkaline; however, the pH ranges from 5.4 (acidic) to 9.4 (highly alkaline). As soil depth increases and the proximity to the underlying calcrete decreases, the alkalinity is seen to rise. The range of soil salinity across Millipede varies based on proximity to the lake and clay pan, with soils across the lake playa and the clay pan being hypersaline.

The dispersiveness of soil across Millipede was also investigated to assess the soil handling methods that would be required to ensure soils are properly managed. Dispersiveness can be related to the sodium content in the soil, especially in the case of fine-grained soils such as clays. Soils that have a high proportion of sodium, relative to the amounts of calcium and magnesium, are described as 'sodic' and may be structurally unstable and susceptible to erosion. The majority of soils were assessed as being non-sodic, although the clay pan soil may be classified as sodic based on the findings across the Centipede deposit (Outback Ecology, 2010g – Appendix 10.63).

Geotechnical drilling has been undertaken at Millipede. The locations are shown in Figure 11.11. Composite samples from this drilling were sent for mineralogical assay and the results of this work are presented in Table 11.2. The results show that there is varied mineralogy across the deposit; however, the mineralogy of the deposit playa is not changed in the processing, and it is only the uranium mineral carnotite that is removed in significant quantities during the process.

Figure 11.11: Geotechnical drilling locations – Millipede

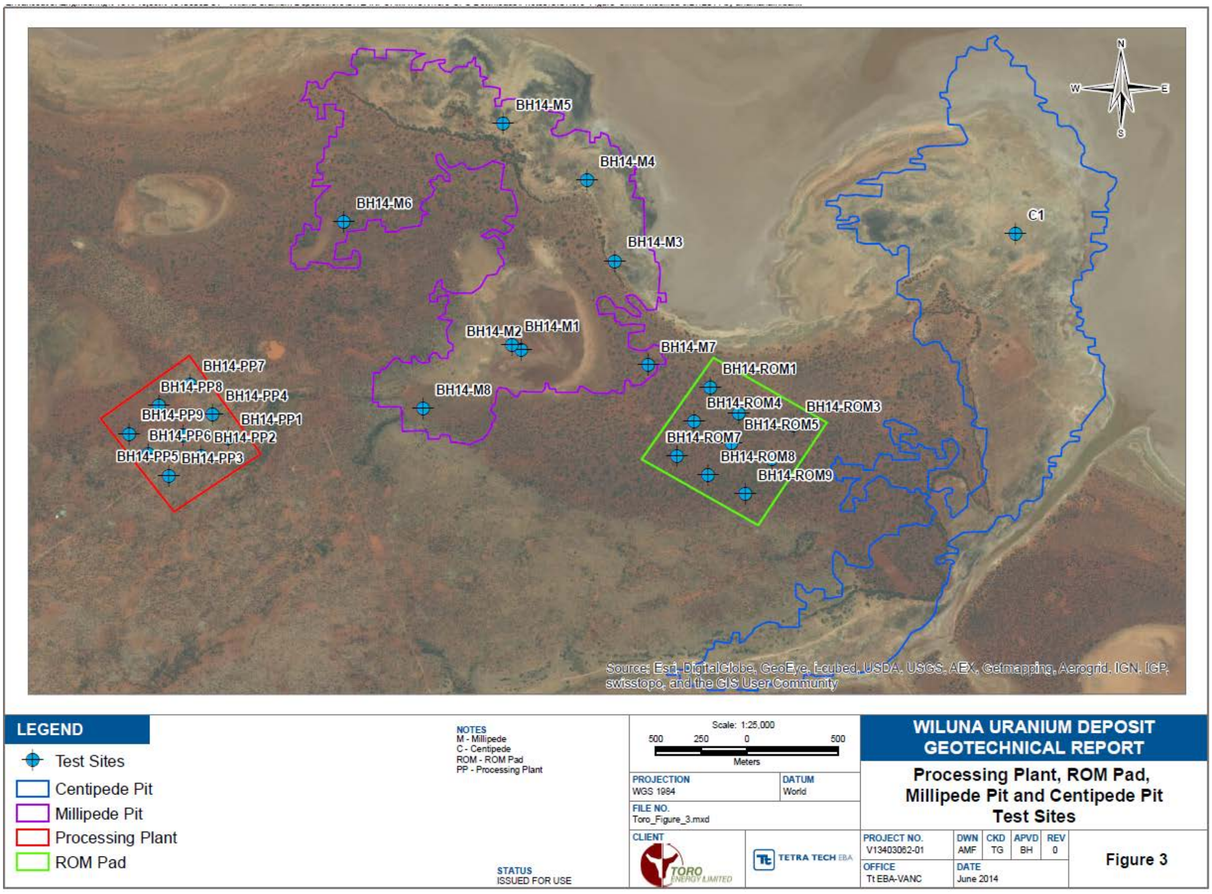


Table 11.2: Rock mineralogical characterisation

Mineral	Mineral Mass Distribution (%)				
	Sample D1	Sample D2	Sample D8	Sample D17	Sample D19
Quartz	51.99	10.54	23.87	33.42	16.50
Feldspars	4.98	0.55	1.63	1.81	1.38
Micas	3.93	0.33	1.21	1.39	1.10
Talc	1.23	8.49	4.25	12.59	7.94
Chlorite	2.09	0.31	1.31	1.44	0.54
Kaolinite Clay	2.47	0.07	0.59	0.48	0.66
Smectite Clay	6.04	1.50	5.31	5.25	3.21
Pyroxene	0.91	3.22	1.11	4.98	2.41
Amphibole	2.17	0.92	5.14	3.14	1.32
Other Silicates	0.56	0.03	0.05	0.09	0.02
Carbonates	16.18	73.06	53.46	33.04	64.00
Ti (Fe) Oxide	0.49	0.03	0.55	0.32	0.06
Fe Ox/Hydrox	3.57	0.63	0.90	1.62	0.51
Other Oxides	0.06	0.03	0.03	0.06	0.02
Ca-Sulphate	0.31	0.02	0.08	0.03	0.02
Celestine	2.87	0.00	0.04	0.00	0.00
Other Sulphates	0.02	0.00	0.01	0.01	0.00
Others	0.13	0.38	0.44	0.32	0.29

Lake Maitland

Table 11.3 presents the results of characterisation analysis of nine overburden samples from the Lake Maitland site. The results show that the pH of the overburden and waste materials were relatively similar and moderately alkaline. The electrical conductivity of the samples varied considerably; however, all sites would be considered highly saline (Outback Ecology, 2011d – Appendix 10.22). Organic material within the waste materials was low and within the expected range of semi-arid soils (Outback Ecology, 2011d – Appendix 10.22). All soils within the region were classified as non-sodic.

There was limited variation in soil textures between the nine overburden waste samples, with soil textures ranging from clayey sand (approximately 10% clay) to sandy clay loam (approximately 20% to 30% clay). The majority of overburden materials were classed as clayey sand or sandy loam (Outback Ecology, 2011d – Appendix 10.22).

Table 11.3: Lake Maitland overburden characterisation

Sample ID	Soil Texture	MOR (kPa)	Soil pH	EC (dS/m)	Organic Carbon (%)	Plant available Nutrients (mg/kg)					Exchangeable Cations (meq/100g)				ESP (%)
						Nitrate	Ammonium	P	K	S	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	
5110-01	Clayey Sand	31.1	8.2	7.62	0.32	15	1	21	466	2441	231.6	0.87	1.48	0.21	0.07
5110-05	Sandy Loam	50.9	8.3	10.82	0.61	17	<1	14	1070	2661	231.9	2.04	1.96	0.43	0.11
5110-06	Clayey Sand	18.6	8	11.14	0.34	10	1	9	1016	2208	230.5	1.27	1.76	0.38	0.11
5110-09	Sandy Loam	5.6	8.1	4.94	0.38	19	1	7	310	2056	108.4	0.29	1.03	0.16	0.08
5111-02	Sandy Clay Loam	13.9	8.2	4.37	0.3	8	1	14	227	3931	244.4	0.41	0.82	0.11	0.07
5111-03	Sandy Clay Loam	59.2	8.9	17.31	1.03	135	1	10	1290	4123	235.2	2.64	3.43	0.53	0.35
5112-02	Sandy Loam	36.1	8.4	9.6	0.43	25	1	10	541	2744	249.7	0.83	1.25	0.27	0.17
5112-04	Clayey Sand	37.0	8.2	13.7	0.49	29	1	9	957	2438	243.9	1.31	1.76	0.38	0.36
5113-01	Sandy Clay Loam	19.5	8.4	10.57	0.45	21	1	23	653	2862	243.9	0.95	1.12	0.25	0.45

Of the nine overburden samples collected, six were identified as slaking and non-dispersive. While slaking can reduce the infiltration capacity of soil, the lack of dispersion indicates that the soils are not prone to be hardsetting. Overburden material from one site demonstrated dispersive properties initially (5113-01), and two sites (5110-01 and 5111-02) demonstrated dispersion upon re-moulding. These overburden materials have the potential to become dispersive and problematic (hardsetting/erodible), particularly following severe disturbance. Care would be taken to minimise the handling of overburden materials particularly when wet. These soils may become dispersive, if there is substantial leaching of salt from the soil profile (Outback Ecology, 2011d – Appendix 10.19).

None of the overburden materials exhibited a tendency for hardsetting. As this test was conducted on reconstructed soil blocks composed of <2 mm soil fraction, it does not take into account the effect of soil structure on soil strength, nor any degree of compaction that may be present in the field. It does, however, provide insight into the relative potential for layers to hard-set and compact with repeated wetting and drying cycles, and the ability of roots to fracture the soil and penetrate crack faces (Outback Ecology, 2011d – Appendix 10.19).

Mineralogical analysis of the waste rock at Lake Maitland was undertaken and the results are presented in Table 11.4.

Table 11.4: Waste rock characterisation at Lake Maitland

Mineral	Mass (%)		
	Average	Minimum	Maximum
Carnotite	<0.2	0.00	0.2
Celestine	3.2	0.00	19.6
Gypsum and Minor Sulphites	1.0	0.2	3.3
Dolomite	38.7	0.2	10.0
Vermiculite	18.1	4.4	45.9
Smectite	18.6	1.4	61.3
Kaolinite	0.6	3.3	43.7
Quartz	14.5	0.4	86.8
Feldspars	2.2	0.0	9.3
Magnesiohornblende	2.1	0.2	6.9
Iron Oxides	0.8	0.1	3.7
Total	**100**	-	-

11.4.10 Geochemical Characterisation of Tailings

The mineralogy of the tails assessment has been undertaken based on the processing methodology developed using Centipede ore. The geochemical analysis of the tailings is presented in Table 11.5. The results of this assessment show that the composition of the mineralogy of solids pre- and post-processing are similar. The liquor contains carbonate and bicarbonate, which are both added during the processing of the ore. The uranium content of the tailings is also reduced as a result of the process, with 90–95% of the uranium removed.

Table 11.5: Tailings chemical composition

Element	Unit	Sample				
		D1	D2	D8	D17	D19
Ag	ppm	<2	<2	<2	<2	<2
Al	%	4.04	0.48	1.66	2.44	1.28
Ba	ppm	400	200	155	200	100
Be	ppm	0.9	0.2	0.2	0.6	0.3
Bi	ppm	<10	<10	<10	<10	<10
C	%	2.94	6.93	8.49	4.41	6.9
C_{org}	%	0.06	0.06	0.12	0.12	0.03
CO_3	%	14.4	34.35	41.85	21.45	34.35
Ca	%	5.3	17.8	13.3	7.6	13.8
Cd	ppm	<5	<5	<5	<5	<5
Co	ppm	10	10	<5	5	<5
Cr	ppm	130	80	80	80	130
Cu	ppm	30	24	32	32	26
Fe	%	3.16	0.38	1.23	1.78	0.88
K	ppm	8600	2000	4000	5500	2900
Li	ppm	20	15	15	25	20
Mg	%	4.08	13.3	8.6	8.12	10.1
Mn	ppm	200	3100	175	800	1600
Mo	ppm	<5	10.00	<5	<5	5.00
Na	ppm	3280	1900	4400	3680	2620
Ni	ppm	20	25	15	45	65
P	ppm	300	<100	500	300	400
Pb	ppm	25	35	15	30	15
S	%	<0.02	<0.02	<0.02	0.02	<0.02
S^{2-}	%	neg	neg	neg	neg	Neg
SiO_2	%	50.8	22.6	23.8	43.8	26.2
Sn	ppm	50	<50	<50	<50	<50
Sr	ppm		142	194	134	116
Te	ppm	<0.2	<0.2	<0.2	<0.2	<0.2
Th	ppm	12	<2	2.7	28	44
Ti	ppm	3200	200	870	1800	600
U	ppm	44.4	25.5	108	41.4	17.4
V	ppm	170	80	115	105	35

Element	Unit	Sample				
		D1	D2	D8	D17	D19
Y	ppm	10	<2	6	6	2
Zn	ppm	28	12	14	22	14
Zr	ppm	70	10	35	45	20
ANC	kg H_2SO_4/t	303	840	714	499	659
Cl	ppm	90	130	480	110	40

11.4.11 Potential for Acid Rock Drainage, Neutral Drainage and Seepage from Stockpiles

There are four key fundamentals to understanding the potential chemistry of drainage from any stockpile or long-term final landform at the Wiluna Uranium Project. They are:

1. All the deposits (Millipede, Centipede, Lake Maitland and Lake Way), like all of the surficial calcrete associated uranium deposits in the region (for example Yeelirrie, Lake Raeside, Nowthanna, Lake Mason, Dawson Hinkler and Thatcher Soak), are located within a completely oxidised setting only 1–2 m from the surface (Toro geological observations (Figure 11.12 and Figure 11.13); Brunt, 1990).
2. All of the deposits are hosted by relatively benign oxidised sands, silts and clays within deltas and playas in broad palaeo-valleys (Toro geological observations (Figure 11.12 and Figure 11.13); Brunt, 1990).
3. Whilst varying amounts of different clay species are present as well as gypsum (the latter mostly above the ore body in the waste), the geochemical environment is dominated by calcium and magnesium carbonate precipitates and concretions (Toro geological observations (Figure 11.12 and Figure 11.13); Brunt, 1990).
4. The ore mineral in all calcrete associated uranium deposits is almost entirely the potassium uranyl vanadate, carnotite ($K_2(UO_2)_2(VO_4)_2 \cdot 3H_2O$), (Brunt, 1990; Cameron, 1990; Bastrakov *et al.*, 2010), a relatively stable mineral within the chemical conditions and timescales relevant to the Wiluna Uranium Project.

Figure 11.12: Geological cross-section – Millipede

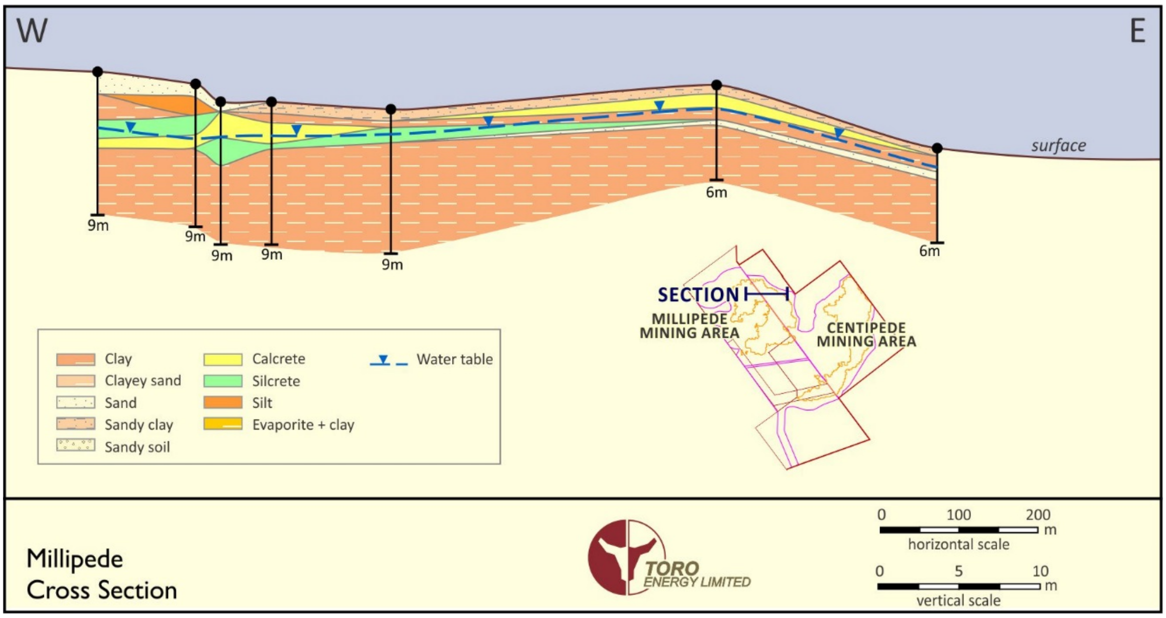
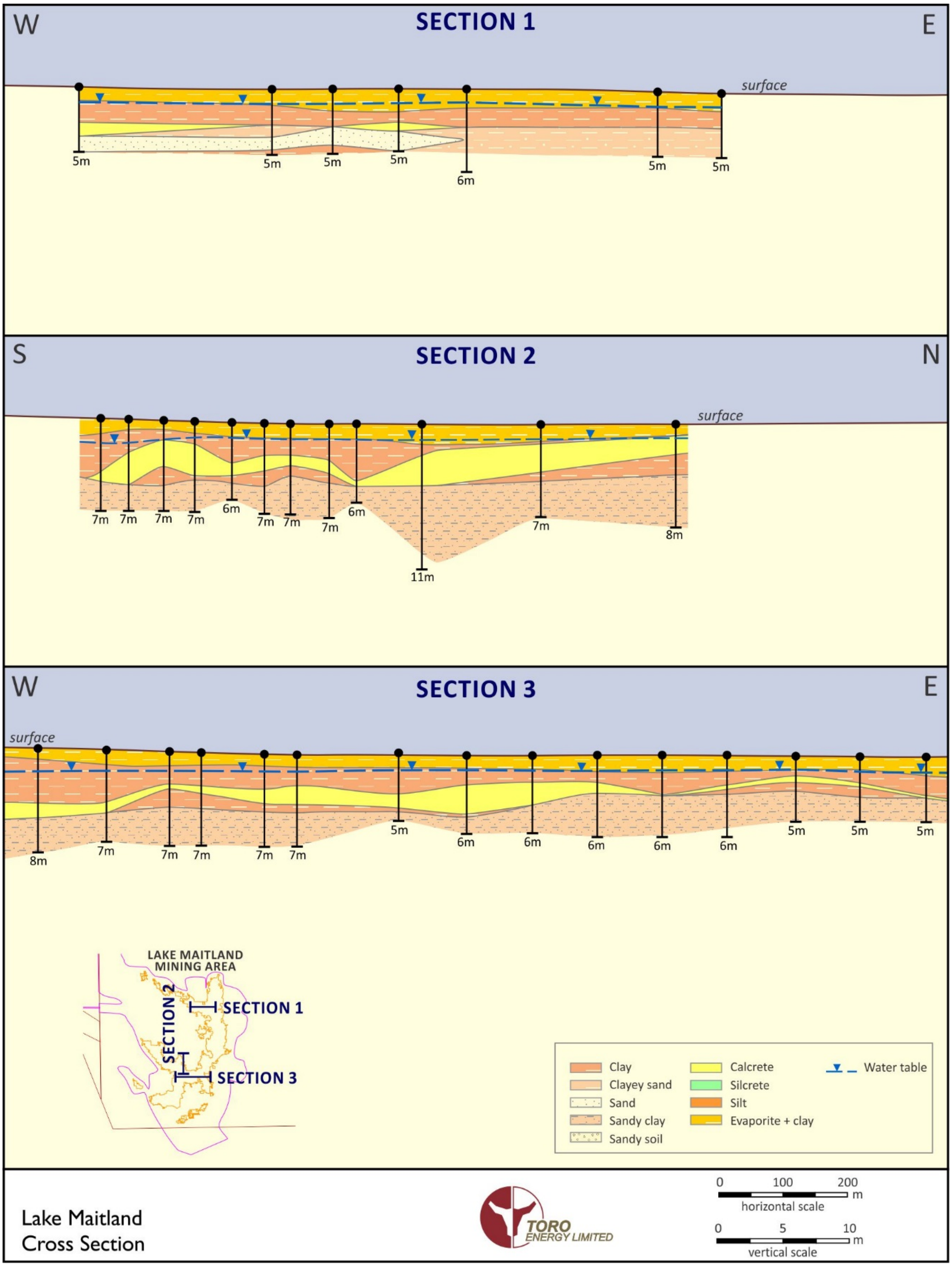


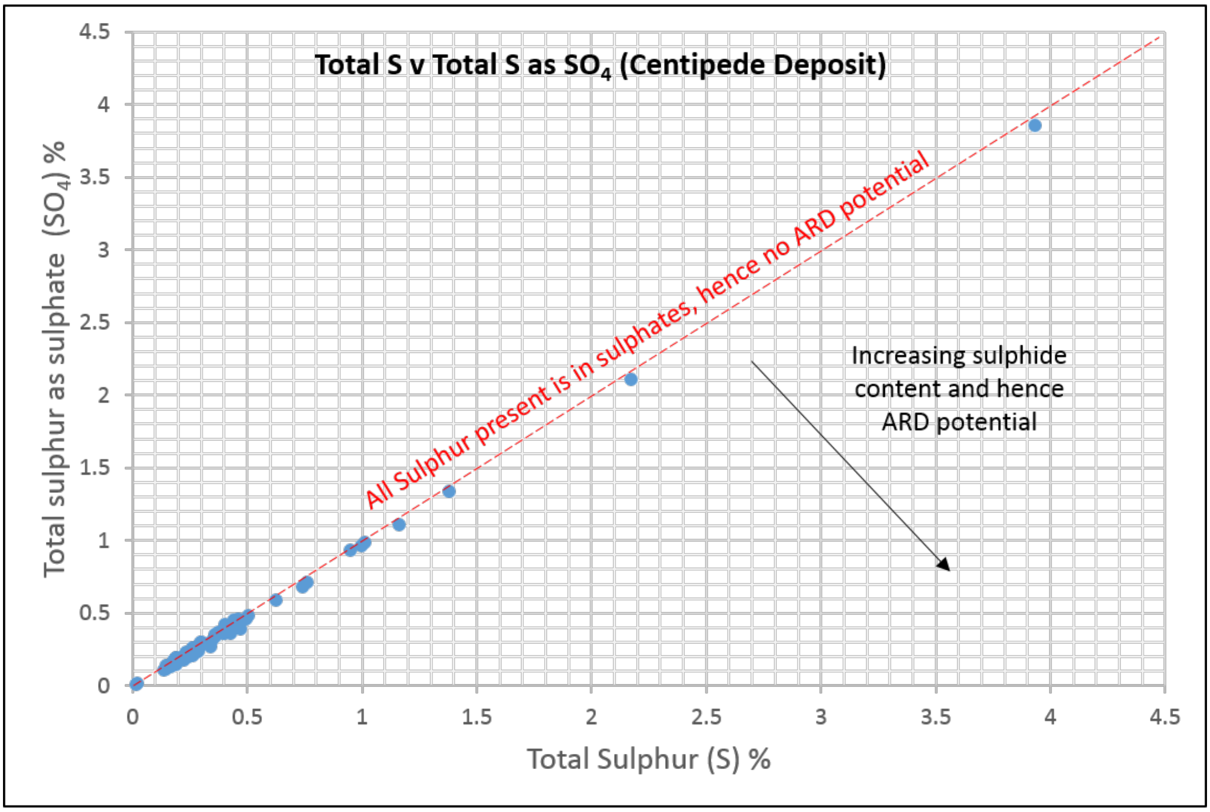
Figure 11.13: Geological cross-section – Lake Maitland



The first of the above fundamentals means that there are no potential acid forming minerals present in the geological host, such as iron sulphides, since such minerals need reducing conditions to form. Toro analysed for both Total Sulphur and Total Sulphate in sonic drill core from a 2012 resource drilling program at Centipede. A comparison of the results shows that all sulphur present is in the form of sulphates (dominantly gypsum), not sulphides (Figure 11.14). Thus, there is no potential for direct acid rock drainage (ARD) nor neutral drainage from acid forming reactions occurring inside the stockpiles or final landforms.

In effect, unlike deeper deposits hosted in hard rock (fresh rock), there is very little difference between the oxidation-reduction conditional balance (commonly known as redox) between the setting of the deposit, at 1–2 m from the surface, to a stockpile at the surface. Changes in redox and the chemistry associated with the main redox chemical reactions are the main controls on weathering, ARD and neutral drainage issues.

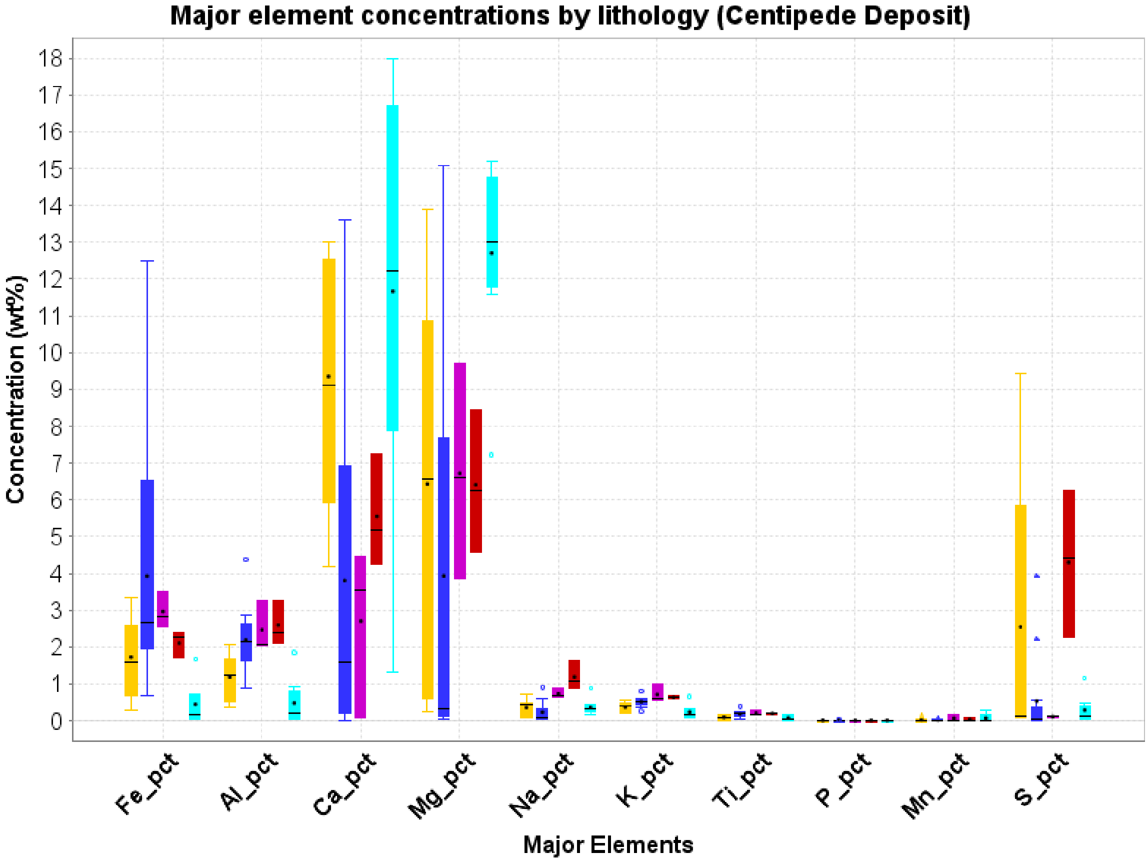
Figure 11.14: Sonic drill core analysis to compare Total Sulphur (S) and Total Sulphate (SO_4)

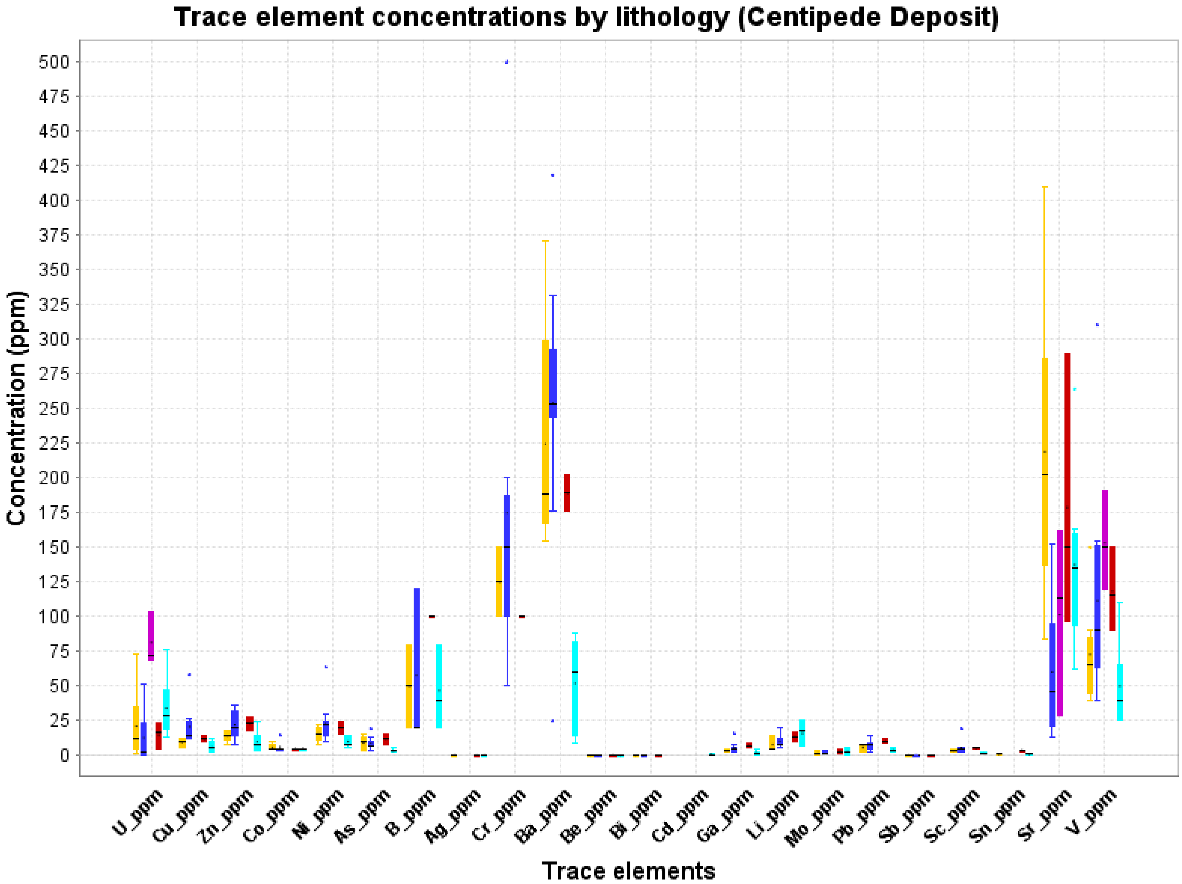


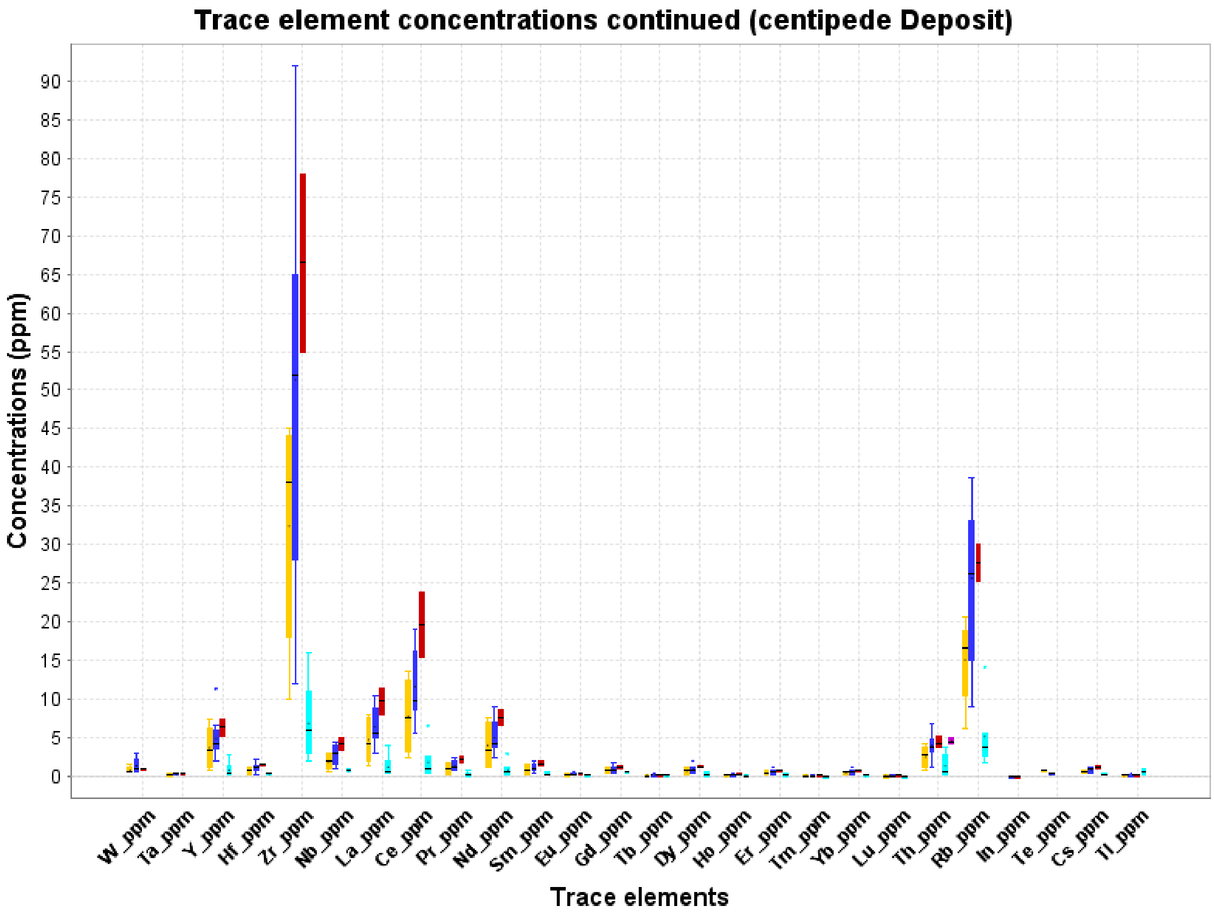
Note: Chart shows that for all intents and purposes, all S is present as SO_4, mostly in the form of gypsum ($CaSO_4{\cdot}2H_2O$), meaning a complete lack of any sulphides and therefore potential production of free hydrogen ions and thus acid rock drainage from the oxidation of them.

In addition to the absence of potential acid forming minerals, the second and third fundamentals above mean that there is very little of most elements available to be leached from the host material if presented to stockpiles. In other words, it is relatively benign material. In Section 16, Table 16.1 provides results of ore leachability tests. Figure 11.15, again from samples of sonic drill core from the 2012 resource drilling, shows major and trace element concentrations in the different lithologies of waste and low grade ore to be extremely low, apart from those related to calcrete and dolocrete (calcium [Ca], magnesium [Mg], barium [Ba] and strontium [Sr]), gypsum (sulphur [S]), some of the more resistate minerals in the sands (iron in iron nodules [Fe], boron [B], chromium [Cr], barium [Ba], zirconium [Zr] and rubidium [Rb]) and the aluminium (Al) in the clays.

Figure 11.15: Major and trace element concentrations in waste and low grade ore lithologies







LEGEND for Figure 11.15

- Calcrete/dolocrete
- Sands
- Silts
- Clays
- Silcrete

Note: Boxplots showing the range of concentrations of major and trace elements in the main lithological units of the Centipede Deposit, Wiluna Uranium Project for waste and very low grade ore (approximately less than 105 ppm U). Samples are from sonic drill core from the 2012 resource drilling program over the Centipede Deposit. The lithological units are the same units used by Toro geologists across all of the Wiluna Uranium Project calcrete associated deposits, including Millipede and Lake Maitland.

The fourth fundamental outlined above relating to the ore mineral in all calcrete associated uranium deposits being carnotite is important because, again, carnotite is a mineral that has precipitated in an oxidised environment and will not be introduced to chemical conditions of any vast difference in the stockpiles or final landforms. Uranium solubility modelling work by Bastrakov *et al.* (2010) has shown that carnotite is a relatively stable solid phase in the environments and timeframes relevant to the Wiluna Uranium Project.

11.5 Potential Impacts

Toro has identified the following potential impacts to terrestrial environment quality associated with implementation of the Proposal:

- Spreading of mineralised material outside the mining areas during ore hauling;
- Increasing radiation levels above background by exposing previously covered uranium ores;
- Loss or deterioration of topsoil and subsoil through poorly planned stockpile locations leading to poor rehabilitation outcomes;
- Localised contamination of soils from erosion of ore;
- Spread of mineralisation in the form of dust;
- Soil contamination from seepage from stockpiles and TSF;
- Localised soil contamination from spills; and
- Long-term contamination of groundwater due to seepages from the TSF.

11.6 Impact Management

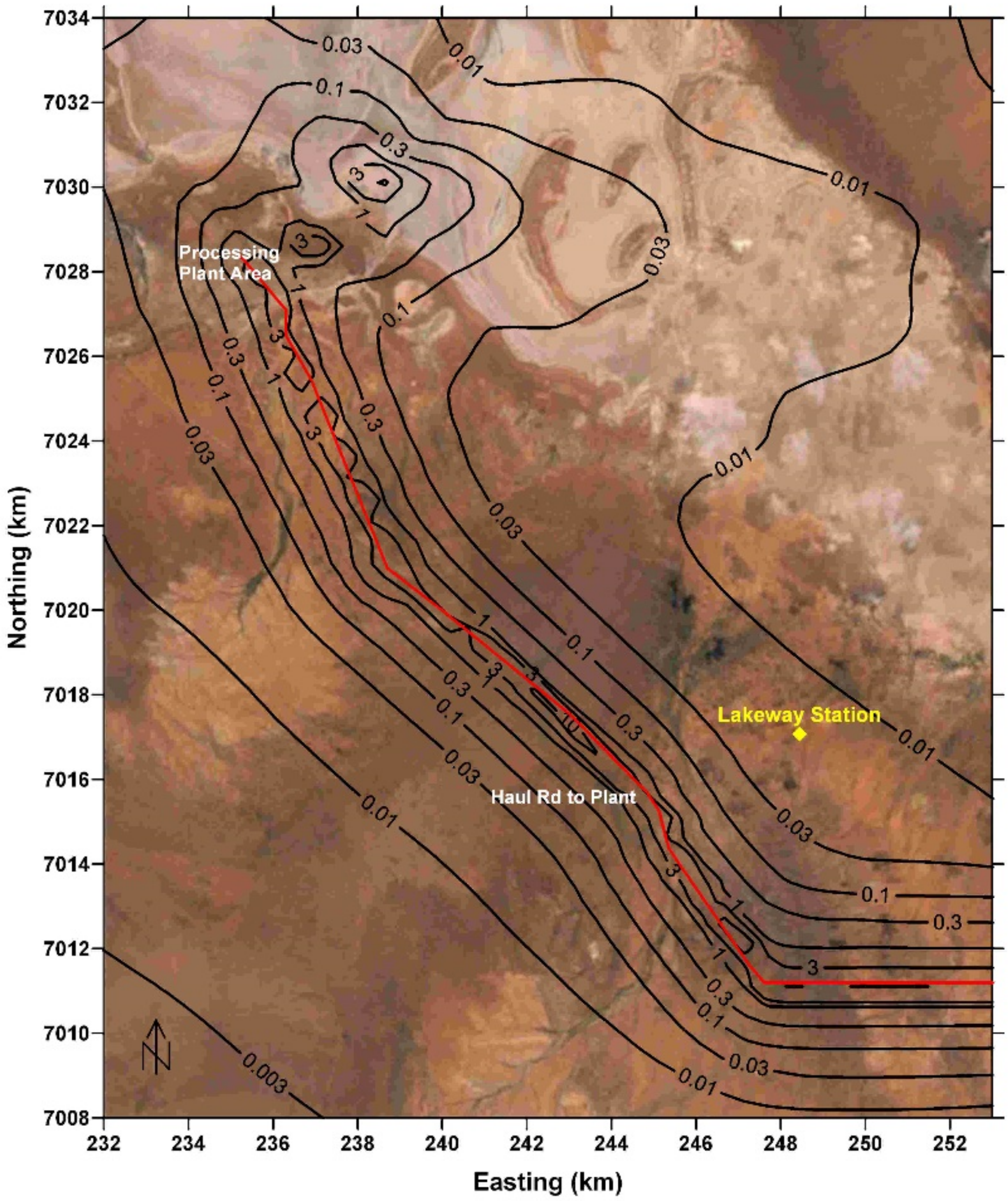
The risk of mineralised material spreading outside areas being mined would be negligible. All ore to be mined is located below the water table and would be wet or moist when removed. This ore would then be transported along dedicated haul roads in covered vehicles to prevent dispersion of ore dust during transport.

Ore, including ore mined at Lake Maitland, would be stockpiled on a ROM pad located centrally between the Millipede and Centipede deposits, approximately 4 km from the boundaries of the mining lease. At the ROM pad dust would deposit at a rate of approximately 10 grams per metre per year (g/m/a) (Air Assessments, 2011). Outside the Millipede mining lease, this would drop to 0.1 g/m/a (Figure 11.7). The red dots in Figure 11.7 show the approximate levels of additional dust deposition at the nearest sensitive receptors. This calculation is for total dust and includes inert dust from dune material and waste rock. Assuming that this dust is all ore with a uranium concentration of 600 ppm, this would mean a total of 0.0072 g/m^2 of uranium would be deposited outside the mining area during a 20 year operational life of the ROM pad. Given the very low volume of uranium deposited, there would be no adverse impact on the environment.

In the dust deposition map for the Lake Maitland deposit (Figure 11.8), the highest level of deposition occurs at the location of the mining pits and mineralised waste stockpiles. In this area 20 g of dust is deposited per square metre per month. As with the Millipede deposit the levels of dust deposition drop off sharply as distance from the mining areas increases. At the edge of the mining lease and the boundary of the operation monthly dust deposition falls to between 0.1 to 0.2 g per square metre per month.

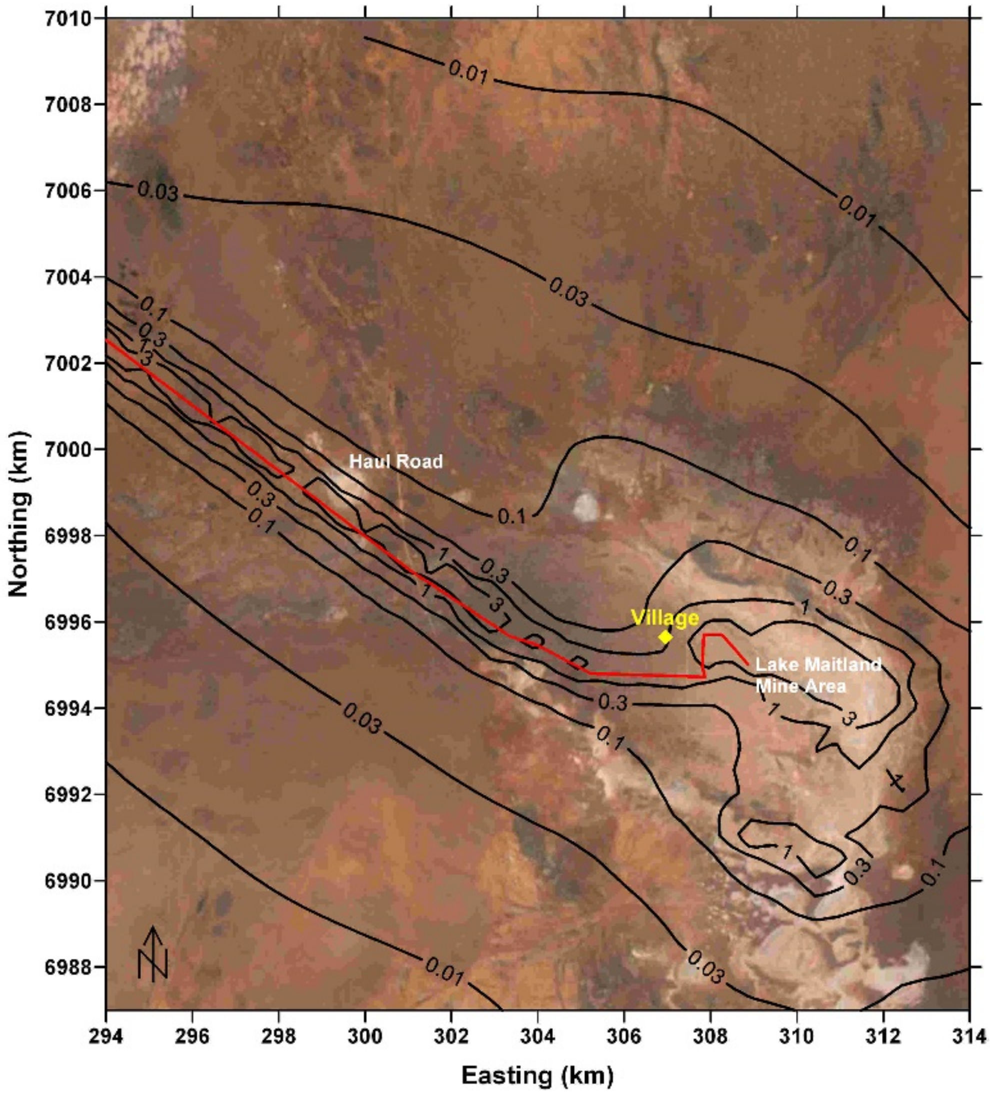
Dust modelling was undertaken to assess the levels of dust that would be generated along the haul road (Figure 11.16 and Figure 11.17). With the use of good base material, propriety binders and regular road watering from trucks, dust control efficiency of 80% is assumed for the haul road. The modelling focussed on only the two ends of the road, as dust deposition along its length is expected to be uniform due to the construction methods. On the road itself, dust generation is expected to be approximately 3 g/m^2/month. As the distance from the road increases the dust levels decrease significantly and within 200 m of the road dust attributed to the haul road has fallen to 0.01 g/m^2/month.

Figure 11.16: Dust generation at western end of haul road



Predicted Annual Deposition Rate Expressed per Month (g/m2/mth) for the Lake Maitland Operations at Nominally Year 11 West End of Haul Road	*Air Assessments* Drawn: ROP 23 July 2015

Figure 11.17: Dust generation at eastern end of haul road



Predicted Annual Deposition Rate Expressed per Month (g/m2/mth) for the Lake Maitland Operations at Nominally Year 11 East End of Haul Road	*Air Assessments*
	Drawn: ROP 23 July 2015

At closure, any mineralised materials located inside the mining area would be returned to the pit to ensure that background radiation levels are restored. Mineralised material would be deposited back into suitable pit voids. Waste rock material would also be returned to pit voids to help restore mined areas, as close as practicable, to natural topography.

From the outset of the mining operations, efficient pre-stripping of the mining and clearing areas would be required to ensure background levels of radiation can be restored. Topsoils and subsoils would be stripped and separately stored for later use in rehabilitation.

During mining operations at both Millipede and Lake Maitland, there would be monitoring and inspections to ensure no build-up of radiation levels, particularly in areas that are undisturbed. If a rise in radiation levels is recorded, the cause would be investigated and the area remediated with engineering controls established to avoid a recurrence.

During the closure of mining areas, remaining mineralised wastes would be returned to the pit and covered with a multi-layer cap to maintain radon emanation to background levels at the surface.

Toro's plans for progressive rehabilitation and maintaining open areas at a minimum would ensure that topsoil removed during mining can be directly returned as soon as possible. This would minimise stockpiling and ensure that natural biological processes in the soil are resumed as quickly as possible.

Where use of topsoil inside the target timeframe is not possible, stockpiling would continue until a suitable use area was available. To prevent the loss of topsoil and subsoil, stockpile locations have already been identified. They would be located outside areas prone to surface water flows, to prevent possible erosion. Topsoil and subsoil stockpiles would be orientated north-east to south-west to minimise exposure to the local winds. A monitoring program assessing the biological activity of stockpiles would be implemented.

It is unlikely that seepage of contaminants from stockpiles and the TSF would be an issue. Toro has undertaken modelling of the TSF to show how the tailings would behave over time. The modelling has shown that under a worst case set of assumptions there is limited potential for contaminants to seep from the TSF. This modelling is explained in greater detail in Section 16, Rehabilitation and Decommissioning.

11.7 Commitments

- Toro will undertake further geochemical modelling of the effects of uranium in local groundwater. This modelling will be done prior to the submission of the Project's Mining Proposal and the results of the modelling will be included in the TSF design in the Project's Mine Closure and Rehabilitation Plan.
- All mine pits would be bunded to a level that withstands a probable maximum flood as required in federal Ministerial Condition of approval 16 (EPBC 2009/5174) for mining at Centipede and Lake Way.
- As far as practicable all stockpiles would be located outside drainage lines and where this was not possible, diversions around the stockpiles would be created.
- All ore and waste stockpiles would be bunded to catch runoff and flow-through water and this water would be used to supress dust on the stockpiles.
- Further engineering studies would investigate methods of dust mitigation or control, including stockpiles and the processing plant.
- Toro would undertake progressive rehabilitation and aim to return waste, overburden and soils as a matter of practice.
- Where soils need to be stockpiled, stockpile height would be capped at 2 m and regular monitoring and inspections would take place.

11.8 Outcome

Based on the studies undertaken so far and the planned future studies and monitoring program, Toro predicts that the Proposal would have no long-term impacts on the quality of the terrestrial environment.

12 SUBTERRANEAN FAUNA

12.1 Objective

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

12.2 Relevant Legislation and Policy

Subterranean fauna are protected under Western Australian and Commonwealth legislation. The applicable state legislation is the *Wildlife Conservation Act 1950* and the EP Act. The applicable federal legislation is the EPBC Act. The EPA provides guidance on its requirements for assessment and management of subterranean fauna through:

- EPA, 2007. Guidance Statement No. 54a *Sampling Methods and Survey Considerations for Subterranean Fauna in Western Australia (Technical Appendix to Guidance Statement 54)*; and
- EPA, 2013a*. Environmental Assessment Guideline (EAG) 12 for consideration of Subterranean Fauna in Environmental Impact Assessment in Western Australia*.

12.3 Background

The Millipede and Lake Maitland uranium deposits have formed as shallow mineralised zones within palaeovalley deltas that flow into Lake Way and Lake Maitland, respectively.

The Millipede deposit is associated with the eastern margin of the Hinkler Well calcrete system located along the edge of the Lake Way playa. The Lake Maitland deposit is associated with the eastern margin of the Barwidgee calcrete system located along the edge of the Lake Maitland playa in the northern section of the Carey palaeodrainage channel. The Lake Maitland borefield does not intersect the Barwidgee calcrete system.

Each of these calcrete systems hosts calcrete stygofauna assemblages that are listed as Priority Ecological Communities (PECs) (DPaW 2015a). Refer to Figure 12.1.

Subterranean fauna may be divided into two main categories:

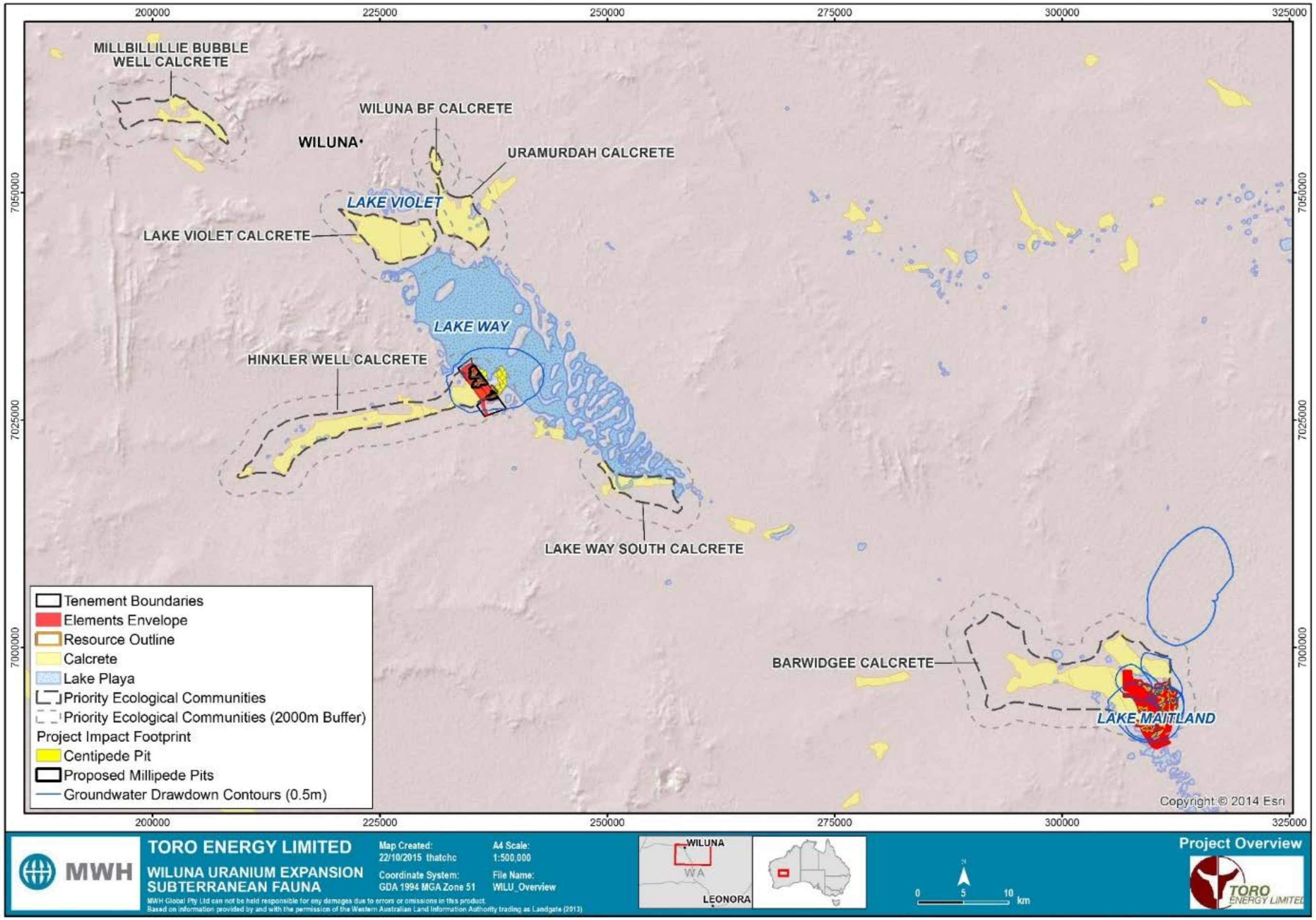
- Stygofauna: Obligate groundwater-dwelling aquatic fauna; and
- Troglofauna: Obligate cave or karst-dwelling terrestrial subterranean fauna occurring above the water table.

Species with a distribution of less than 10,000 sq km are considered to be SREs more vulnerable to extinction (Harvey 2002) and therefore have intrinsic conservation value. Both stygofauna and troglofauna are typically confined to subterranean habitats and commonly represent short range endemic species (SREs) with distributions often restricted to the extent of geographically isolated 'subterranean island' habitats such as an inhabited aquifer system or geological formation.

12.3.1 Stygofauna

Stygofauna spend their entire lifecycle below ground. They are predominantly invertebrates. They display characteristics typical of a subterranean existence which include a reduction or absence of pigmentation, absence or reduction of eyes, and the presence of extended locomotory and sensory appendages (Watts and Humphreys, 2000). Stygofauna are considered to be an ancient group with Pangaean, Gondwanan and Thethyan origins and are thought to have sought refuge below ground with the onset of aridity in Western Australia during the Tertiary age (Cooper *et al.,* 2002; Humphreys *et al.,* 2004).

Figure 12.1: Subterranean fauna PECs



With the formation of the palaeorivers in the late Tertiary and the subsequent calcretes, the aquatic invertebrate fauna associated with the rivers and the hyporheic zone (living in between the soil particles of the river bed) took refuge in the subsurface caverns that had formed and remained, evolving into distinct communities (Humphreys, 2001).

Typical groundwater habitats for stygofauna are megavoids, such as large caves, mesocaverns in karst and basalts, and the interstitial spaces of alluvial aquifers. An increase in subterranean surveys over the last decade has shown Western Australia to have a significant diversity of stygofauna and troglofauna within a relatively small area (Eberhard *et al.* 2009, Halse and Pearson 2014, Humphreys 2006, Humphreys *et al.* 2004).

Calcrete associated groundwaters are recognized as providing suitable habitat for stygofauna in the Pilbara and Yilgarn and, as such, generally host more diverse and abundant assemblages than regolith or fractured rock associated aquifers (Allford *et al.* 2008, Cooper *et al.* 2008, Environmental Protection Authority 2007 , Humphreys 2008).

Stygofauna have been relatively well documented within the Lake Way and Lake Maitland areas, with over 60 species documented from the Hinkler Well, Barwidgee, Lake Violet and Uramurdah (Humphreys *et al.* 2009: Outback Ecology 2012a).

The assemblage includes the crustacean groups Bathynellacea (Abrams *et al.* 2012, Cho and Humphreys 2010, Cho *et al.* 2006, Guzik *et al.* 2008), Copepoda (Karanovic 2004, Karanovic and Cooper 2011), Isopoda (Taiti and Humphreys 2001), Amphipoda and Ostracoda (Karanovic and Marmonier 2002), as well as stygal diving beetles (Coleoptera) (Leijs *et al.* 2003, Watts and Humphreys 2000, 2003, 2006, 2009).

12.3.2 Troglofauna

Troglofauna (terrestrial subterranean fauna) are often relictual forms related to surface dwelling (epigean) groups and can be distinguished by characteristics associated with a below ground existence (Humphreys 2000a).

As they are restricted to subterranean environments, troglofauna generally lack pigmentation, are blind or have reduced eyes, have elongated limbs, and may possess enhanced non-visual sensory adaptations (Culver *et al.* 1995).

Troglofauna are found worldwide and have until recently been classified as cave or well-dwelling organisms (Culver and Sket 2000). Significant areas for troglofauna in Western Australia are the Cape Range and Barrow Island karst cave systems, where large and diverse communities have been discovered in extensive cave systems (Hamilton-Smith and Eberhard 2000).

The discovery of diverse troglofauna communities in subsurface rock fractures in non-karst areas in the 1980s prompted broader consideration of potential habitat (Juberthie 2000). Surveys have identified troglofauna from non-karstic geologies such as vuggy pisolite ore beds in the Pilbara region, and calcrete and metamorphic mafic rocks in the Yilgarn (Barranco and Harvey 2008, Bennelongia 2009, Outback Ecology 2011h - Appendix 10.64, Subterranean Ecology 2008).

The microhabitats hosted within these geologies sustain relatively high humidity levels that meet the requirements for an estimated 4000 species (mostly undescribed) or more across the arid/semi-arid western half of Australia (Guzik *et al.* 2011).

The troglofauna assemblages of the calcrete systems associated with Lake Way and Lake Maitland are less diverse than the resident stygofauna assemblages present and have received less attention in the scientific literature. A recent genetic study (Harrison *et al.* 2014) found troglobitic pseudoscorpions species exhibited strong geographic structuring including among the Lake Way associated calcrete systems.

12.4 Proponent Studies and Investigations

The terms used in this section to define the various areas of the Project's subterranean fauna assessments are:

- Millipede survey area – includes all survey sites in the Hinkler Well calcrete area. This encompasses the previously approved Centipede mining area (mining disturbance area including pit voids and waste stockpiles), as well as the proposed Millipede mining area.
- Lake Maitland survey area – includes all survey sites in the Barwidgee calcrete area. This encompasses the proposed Lake Maitland mining area (mining disturbance area including pit voids and waste stockpiles), as well as the Lake Maitland borefield area.

Sample locations are shown in Figure 12.2 to Figure 12.5.

12.4.1 Survey Effort – Millipede/Centipede

Toro commissioned Outback Ecology (now MWH) to conduct a series of subterranean fauna surveys between July 2007 and November 2010 for the original Wiluna Uranium Project (EPA Assessment 1819 and EPBC 2009/5174).

Further subterranean fauna surveys were carried out in November 2011 and January 2012 (Outback Ecology, 2012a – Appendix 10.26) as part of Toro's response to submissions on the ERMP for the Wiluna Uranium Project. The survey reports by Outback Ecology, and those for Lake Maitland referred to below, have been peer reviewed by Ecologia (2014e – Appendix 10.39).

The Millipede deposit is directly adjacent to the previously assessed Centipede deposit (EPA Assessment 1819 and EPBC 2009/5174). Both deposits are associated with the Hinkler Well calcrete on the western margin of the Lake Way playa. The potential impact on subterranean fauna of proposed development of the Millipede deposit had not been specifically assessed previously, although findings from the Level 2 baseline assessment of Centipede are directly relevant to an assessment of Millipede.

On this basis it was agreed between Toro and the OEPA that a targeted survey across the Millipede deposit for both stygofauna and troglofauna would suffice to understand the subterranean values of this portion of the Hinkler Well calcrete. Targeted surveys were carried out between January and April 2015 and formed an extension to the previously completed Level 2 survey assessment (Outback Ecology 2011h - Appendix 10.64; Outback Ecology 2012a – Appendix 10.26; MWH 2015 – Appendix 10.11).

Stygofauna

The Millipede targeted survey and the previous Centipede assessment resulted in the collection of a total of 106 stygofauna samples from 82 bores over six survey periods from July 2007 to January 2012. Some 85 samples were collected from inside the combined Millipede and Centipede impact zones (Table 12.1 and Figure 12.2). Ten samples were collected from within the proposed Millipede pit boundary.

Figure 12.2: Millipede stygofauna sampling locations

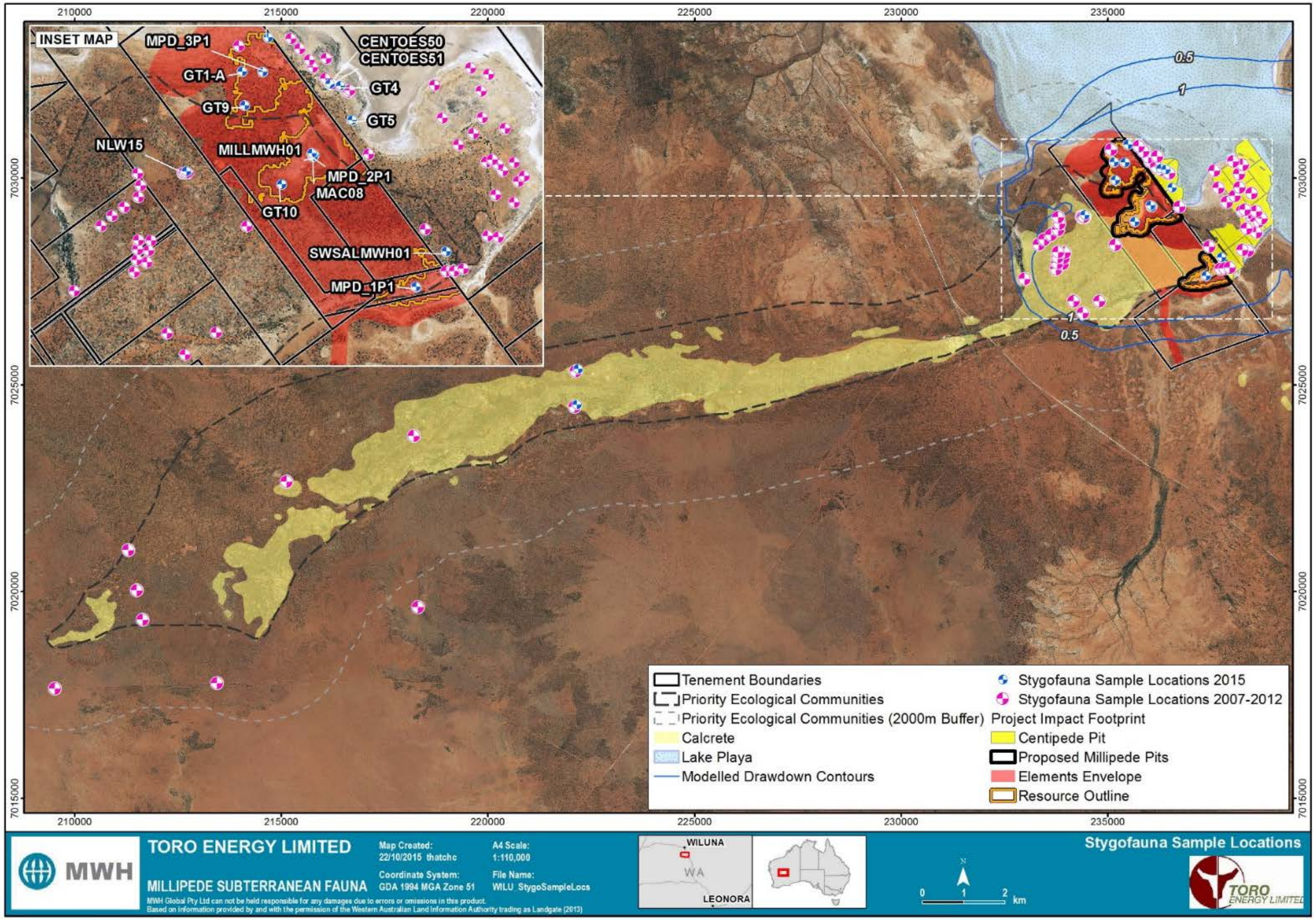


Table 12.1: Stygofauna sampling effort (Millipede/Centipede)

Survey Date	Impact Sites	Non-impact Sites	Total Sites Sampled
July 2007	40	1	41
November 2009	20	10	30
August 2010	2	2	4
November 2011	4	3	7
January 2012	4	3	7
January 2015	15	2	17
No. Samples	85	21	106
No. Bores	70	11	82

Troglofauna

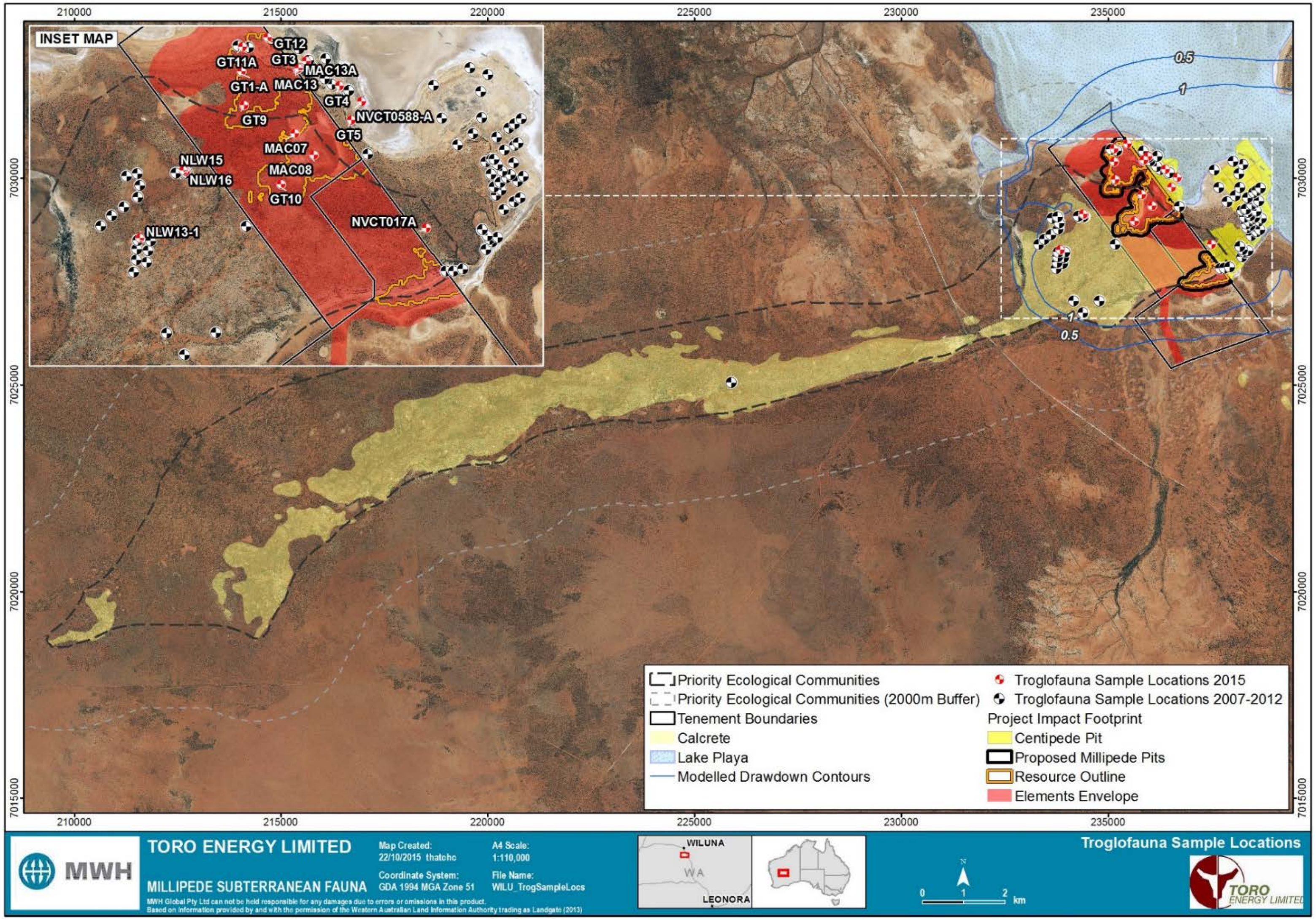
The Millipede targeted survey and the previous Centipede assessment resulted in the collection of 151 troglofauna samples from 97 bores during six survey periods from July, 2007 to January, 2015. Table 12.2.

A total of 147 samples were collected from inside the combined Millipede and Centipede impact areas (Outback Ecology 2011h – Appendix 10.64; MWH 2015 – Appendix 10.11). Ten samples were located within the proposed Millipede pit boundary. Results and locations are shown in Table 12.2 and Figure 12.3.

Table 12.2: Troglofauna sampling effort (Millipede/Centipede)

Survey Date	Impact Sites	Non-impact Sites	Total Sites Sampled
July 2007	40		40
November 2009	41		41
March 2010	37		37
August 2010	2		2
November 2011	9	4	13
January 2015	17		17
No. Samples	147	4	151
No. Bores	93	4	97

Figure 12.3: Millipede troglofauna sampling locations



12.4.2 Survey Effort – Haul Road

Subterranean fauna studies have not been conducted in connection with the proposed haul road, as the direct disturbance arising from road development would result in minimal impact to subterranean fauna habitats. No dewatering and limited evacuation is required as part of haul road development.

12.4.3 Survey Effort – Lake Maitland

Baseline surveys of stygofauna and troglofauna were conducted at Lake Maitland in 2007, 2008 and 2010 (Outback Ecology 2012c – Appendix 10.28: Outback Ecology 2012b – Appendix 10.27). A small reconnaissance survey completed in January 2007 confirmed the presence of stygofauna at Lake Maitland and led to a more intensive survey in May 2007. A third survey, incorporating both previously sampled and additional sites, was undertaken in December 2008. A fourth survey was completed in March 2010 with predominantly new sites surveyed.

The subterranean fauna surveys were designed to provide a relatively broad geographical spread of samples from within representative geologies of the proposed impact areas, as well as from within representative areas outside where mining and infrastructure development would occur at Lake Maitland. Bores sampled were situated within a range of surface geologies ranging from clayey colluvial sands around the shoreline of the lake playa through to calcrete geologies associated with the Barwidgee calcrete.

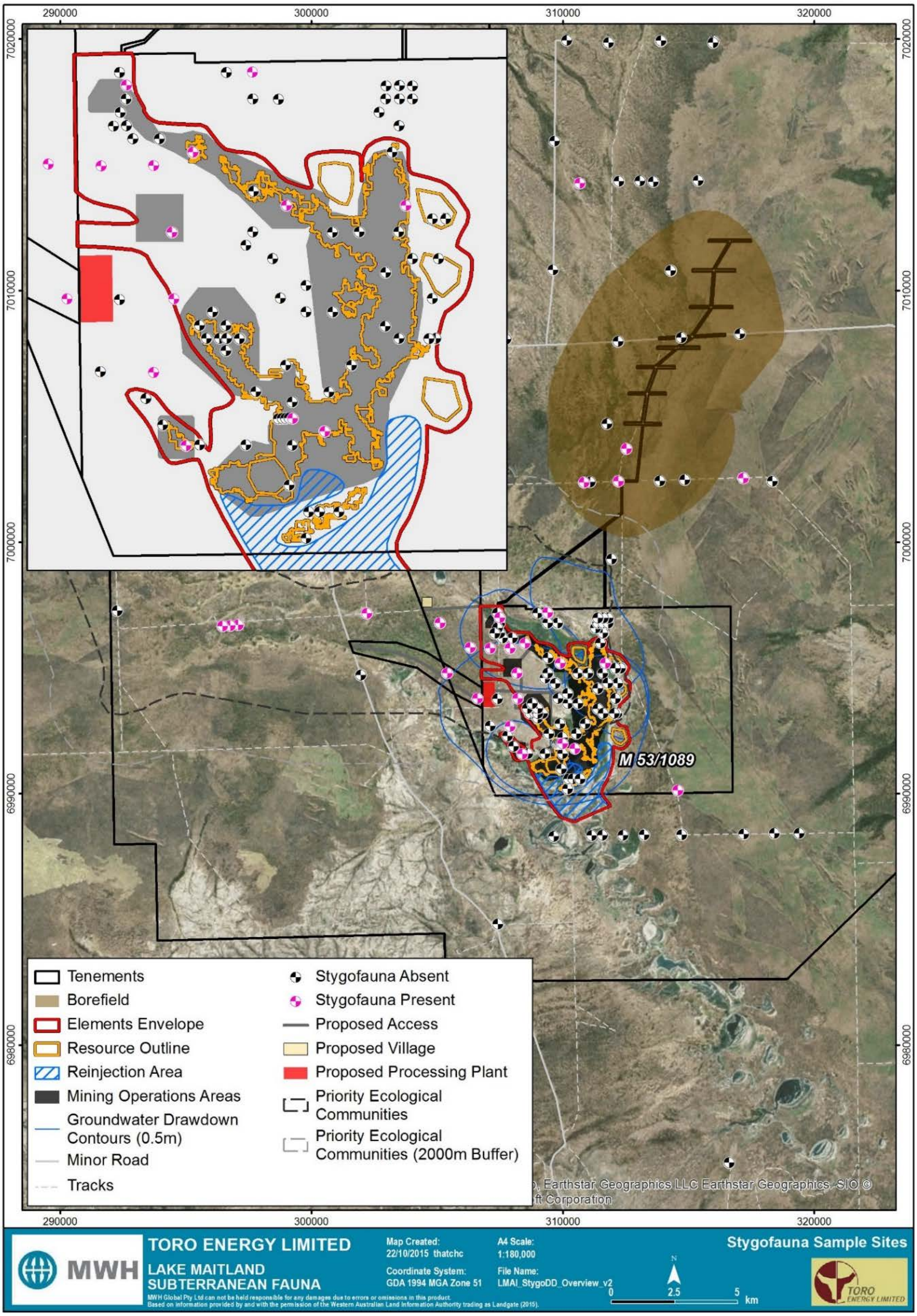
Stygofauna

Stygofauna sampling resulted in the collection of 165 net haul samples from 87 holes over ten rounds of sampling in January 2007, May 2007, December 2008, March 2010, August 2010, February 2011, March 2011, July 2011, September 2011, and November 2011 (Outback Ecology 2012c – Appendix 10.28). A total of 90 stygofauna samples were collected from within the proposed Lake Maitland pit boundary and associated 0.5 mbSWL groundwater drawdown and 21 samples were collected from within the proposed Borefield 0.5 mbSWL groundwater drawdown. Results and locations are summarised in Table 12.3 and Figure 12.4.

Table 12.3: Stygofauna sampling effort (Lake Maitland)

Survey Date	Impact Sites	Non-impact Sites	Total Sites Sampled
January 2007	3	6	9
May 2007	19	4	23
December 2008	25	6	31
March 2010	18	2	20
August 2010	14	2	16
February 2011	8	9	17
March 2011	14	1	15
July 2011	10	18	28
September 2011		3	3
November 2011		3	3
No. Samples	111	54	165
No. Bores	64	23	87

Figure 12.4: Lake Maitland stygofauna sampling locations



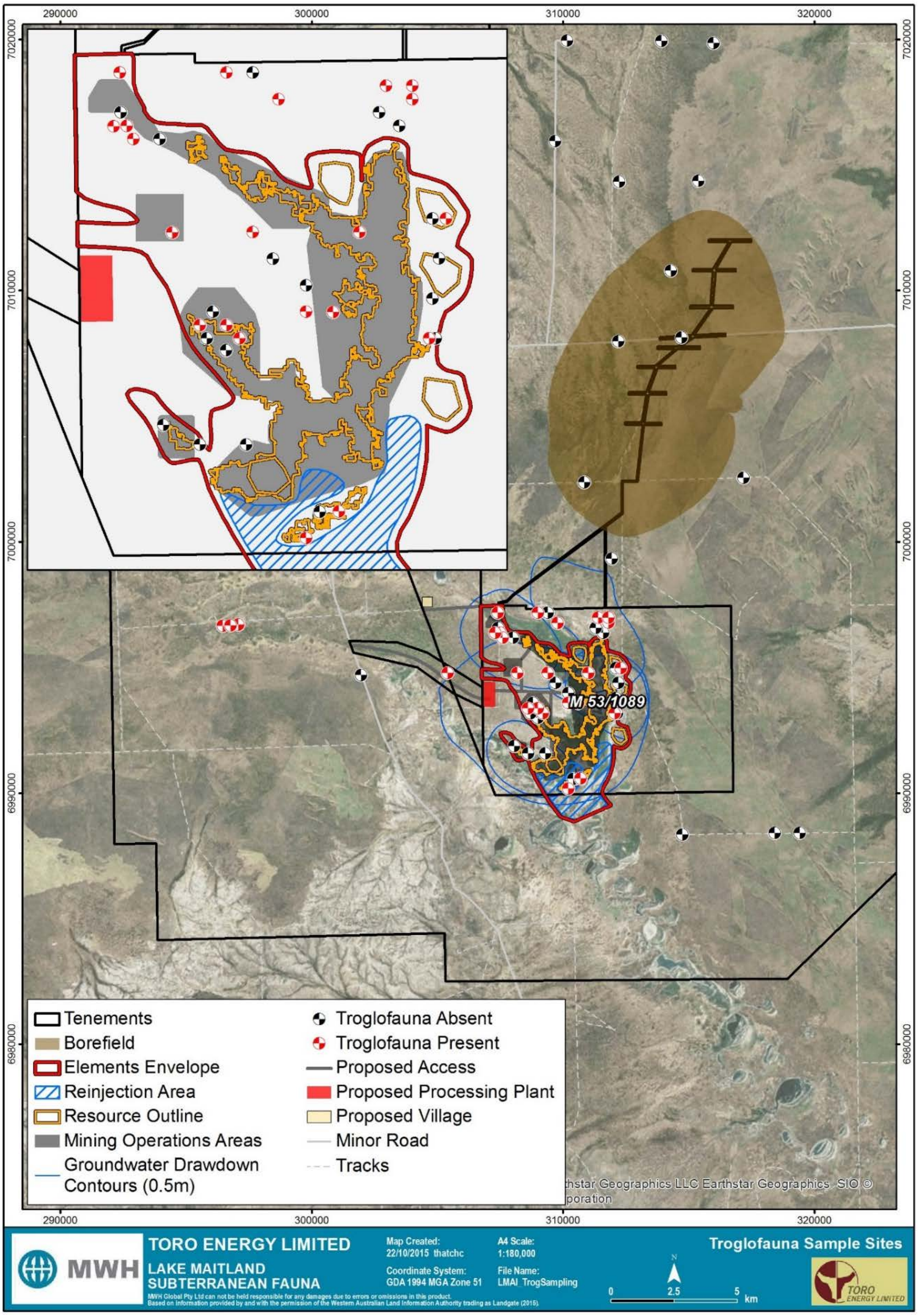
Troglofauna

Troglofauna investigations at Lake Maitland resulted in the collection of 92 litter trap and 18 scrape samples during six survey periods (Outback Ecology, 2012b – Appendix 10.27). Some 73 samples were collected from within the proposed mining operations impact area. A total of 12 troglofauna samples were recovered from within the nominal 0.5 mbSWL groundwater drawdown zone associated with the proposed Lake Maitland borefield. Results and locations are shown in Table 12.4 and Figure 12.5.

Table 12.4: Troglofauna sampling effort (Lake Maitland)

Survey Date	Impact Sites	Non-impact Sites	Total Sites Sampled
May 2007	2		2
December 2008	1		1
August 2010	1		1
November 2010 to January 2011	43	5	48
March to May 2011	38	9	49
September to November 2011		9	9
No. Samples	85	25	110
No. Bores	48	14	62

Figure 12.5: Lake Maitland troglofauna sampling locations



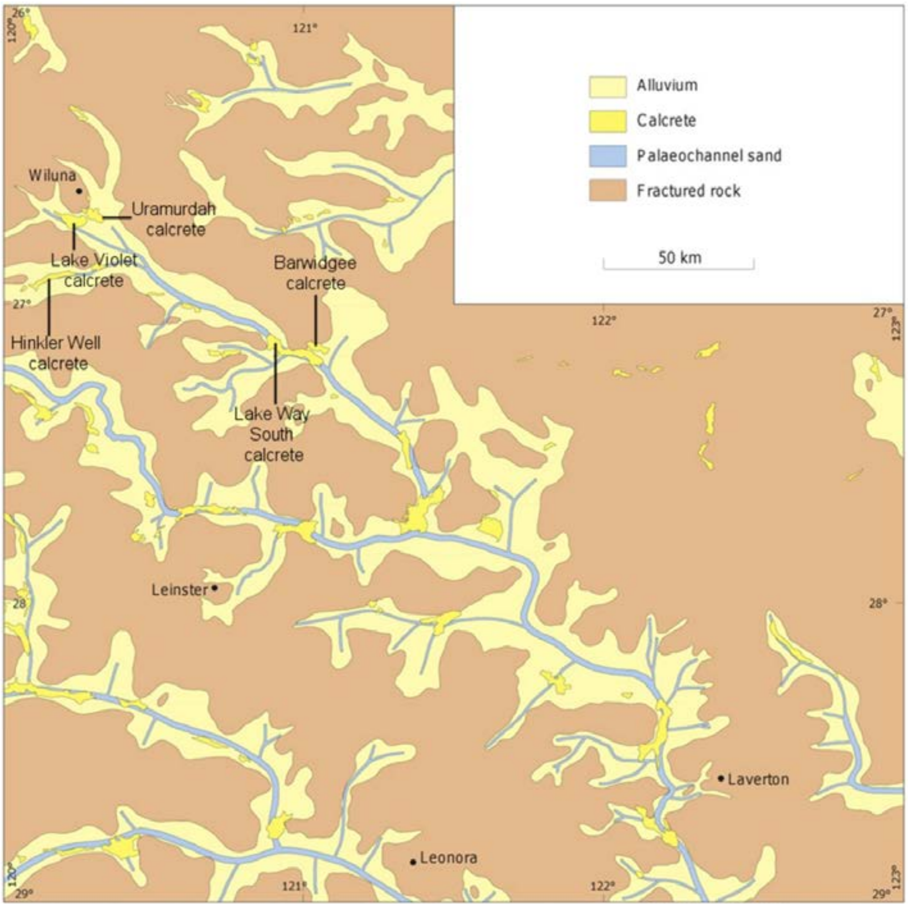
12.5 Existing Environment

12.5.1 Subterranean Fauna Habitat

There are four main aquifer types of relevance to stygofauna habitat shown in Figure 12.6:

- fractured rock aquifers;
- palaeochannel aquifers;
- alluvial/colluvial aquifers; and
- calcrete aquifers.

Figure 12.6: Regional occurrence of the main aquifer types



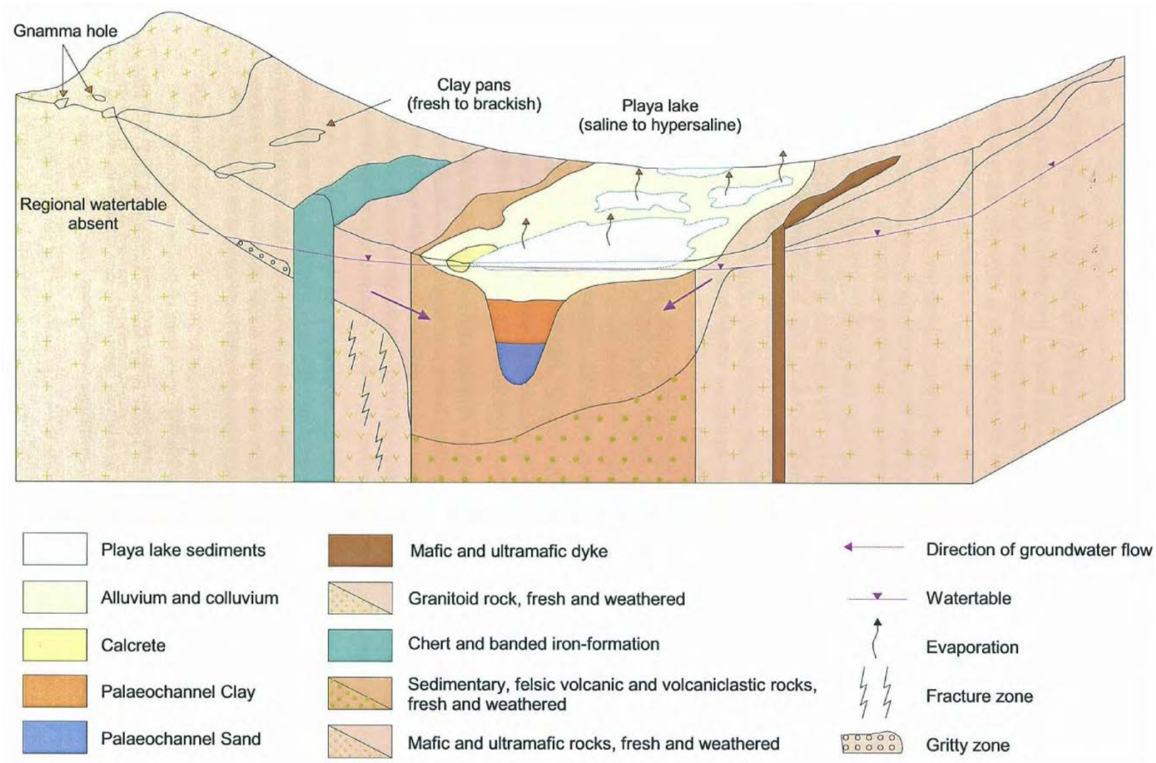
Source: Johnson et al. (1999)

The two main regional aquifer types of relevance to stygofauna habitat associated with different geological units in the area surveyed are:

- Calcrete Aquifers. Associated with the extensive Hinkler Well calcrete system (Aquaterra 2010a - Appendix 10.57). Calcrete formation is generally associated with low lying areas, where the water table is shallow (~5 m below ground level) (Johnson 2004)
- Alluvium and Colluvium. The Tertiary Palaeochannel sedimentary layers are overlain by more recent alluvial and colluvial deposits, typically silty sands and minor gravels (Johnson 2004, Johnson *et al.* 1999). Refer to Figure 12.7.

Of these two aquifer types, calcrete habitats are more likely to constitute significant stygofauna habitat.

Figure 12.7: Diagrammatic representation of major geological units in Carey Palaeodrainage



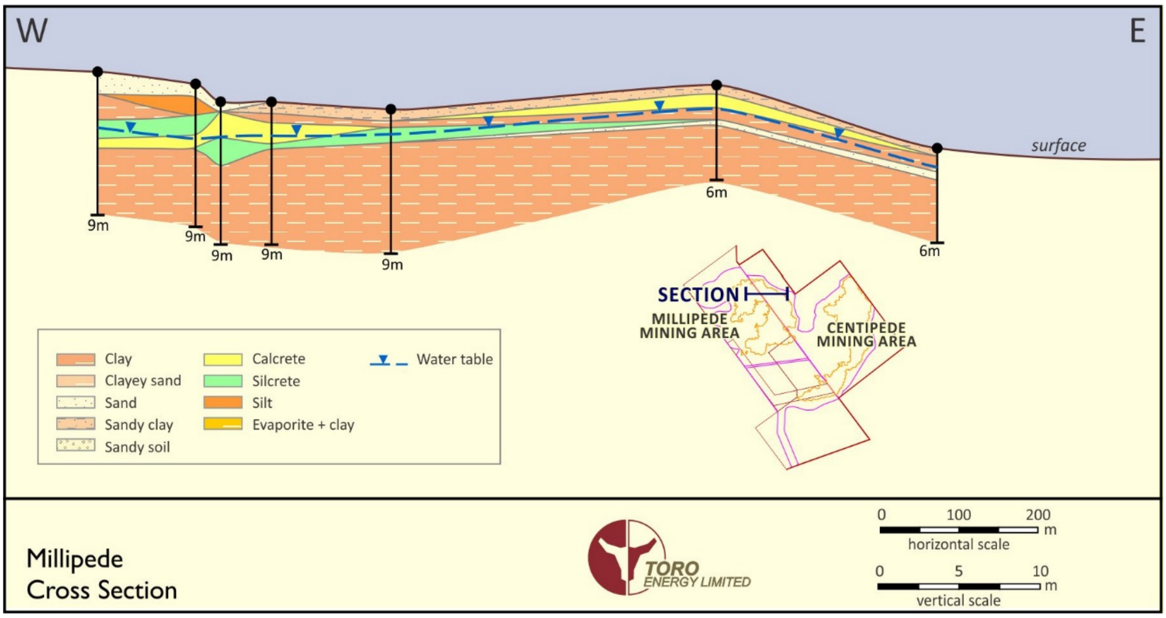
Source: Johnson et al. (1999)

Calcrete bodies are characterised by high secondary permeability and they often contain lower salinity water than other aquifer types. Calcretes are generally considered to provide suitable stygofauna habitat in the Australian arid zone (Allford *et al*. 2008, Cooper *et al*. 2008, Environmental Protection Authority 2007, Humphreys 2008). The significance of the stygal assemblages in the Lake Way and Lake Maitland associated calcrete systems has been recognised through the declaration of PECs (Humphreys 2001, Humphreys *et al.* 2009, Outback Ecology 2011h - Appendix 10.64, Outback Ecology 2012c - Appendix 10.28 and Outback Ecology 2012a - Appendix 10.26).

Over time, palaeochannels have gradually been filled in by eroded sediments from greenstone and granitoid bedrock, with a surficial layer of more recent, colluvial material (Figure 12.7). In parts of palaeodrainage channels, calcrete has formed within the surficial layer (Johnson *et al.* 1999). Cainozoic calcrete bodies are common in drainage lines and around the margins of salt lakes in the Yilgarn at latitudes north of 29°S (Anand and Paine 2002, Johnson *et al*. 1999, Morgan 1993). Other surficial geology includes sandplain and sheetwash deposits, alluvium and colluvium (Aquaterra 2010a - Appendix 10.57, Aquaterra 2010d and Aquaterra 2010e). The Lake Way playa primarily comprises Cainozoic saline and gypsiferous evaporites, clays and mud, with bordering dunes of sand, silt, evaporites and carbonates (Aquaterra 2010a - Appendix 10.57, Aquaterra 2010e).

The Millipede deposit is situated near the northern end of the Carey palaeodrainage. The Lake Way playa primarily comprises Cainozoic saline and gypsiferous evaporites, clays and mud, with bordering dunes of sand, silt, evaporites and carbonates (Aquaterra, 2010d; Aquaterra 2010e). A typical cross section of the shallow subsurface geology at Millipede and Centipede is shown at Figure 12.8.

Figure 12.8: Geological cross-section between Millipede and Centipede deposits

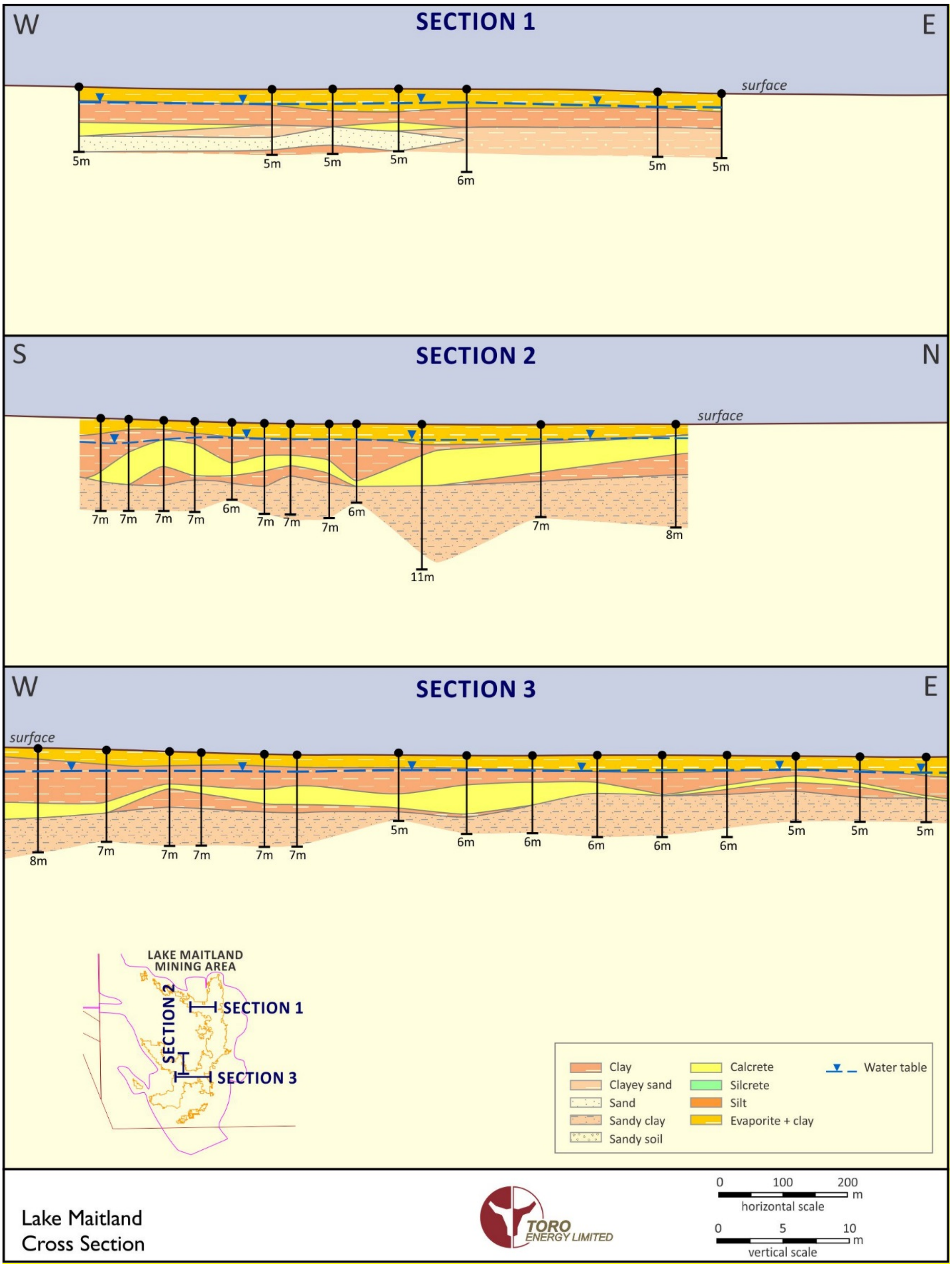


Lake Maitland is also located within the Carey palaeodrainage system. Sediments of the Lake Maitland playa mostly comprise clays. The Lake Maitland uranium deposit is hosted in a shallow calcrete deposit, with a mineralised zone of 1 m to 3 m thick, 300 m to 1500 m wide and about 6 km long, extending in a north-south arcuate zone into both westerly arms of the playa. The stratigraphy of Lake Maitland deposit is illustrated in Figure 12.9.

Groundwater salinity in the Hinkler Well calcrete aquifer has been found to range from 1600 TDS (at Abercromby Well) to between 32,000 and 57,000 TDS within the Millipede deposit and 66,000 and 330,000 TDS within the Centipede deposit, increasing markedly towards the delta area of the playa (Mann and Deutscher 1978, Aquaterra 2010d).

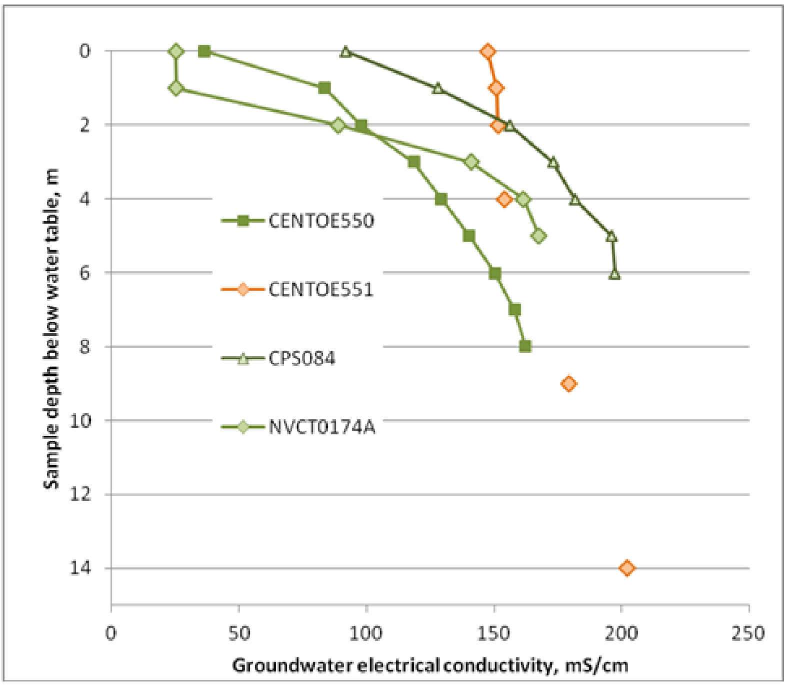
Groundwater salinities typically increase down gradient along the regional flow path. Salinity also tends to increase with depth, reflected in the hypersaline conditions recorded from the deeper palaeochannel in the area (Outback Ecology 2012a - Appendix 10.26, Aquaterra 2010d). A similar pattern of groundwater salinity occurs within the Barwidgee Calcrete. Salinity in the calcrete aquifer near Lake Maitland varies depending on proximity to the playa, ranging from <5,000 mg/L to over 100,000 mg/L (Golder Associates 2011c).

Figure 12.9: Geological cross-section – Lake Maitland



As part of its baseline assessment, Toro has conducted a limited amount of groundwater salinity profiling in 2011 and 2015. Within the Hinkler Well calcrete, salinities tend to decrease with distance from the playa. The lowest values observed during baseline surveys were generally recorded from bores west of the Goldfields Highway. The thickness of the freshwater stratum ranged from greater than 24 m at bore SB26-1, approximately 20 km west of the lake playa to less than 1 m at NVCT074A approximately 1.5 km from the lake playa. Below the thin freshwater layer at NVCT074A, the groundwater salinity increased rapidly, becoming hypersaline at a depth of about 3 m below the groundwater table and continuing to increase to the maximum depth of sampling (6 m below the water table). Closer to the lake playa, at CENTOES51 for example, groundwater was hypersaline from the groundwater table, increasing gradually with depth (Figure 12.10).

Figure 12.10: Variation in groundwater salinity with depth – Hinkler Well calcrete (various locations)



Groundwater parameters recorded from the Millipede deposit bores in 2015 followed a similar trend with salinity levels in the northern part of the deposit ranging from freshwater to mesosaline (11,000 mg/L to 46,000 mg/L (mean 25,200 mg/L)) just beneath the surface of the standing water column and becoming hypersaline conditions (> 80,000 mg/L) at depths greater than about 2 m below the water table. Groundwater is generally more saline in the southern section of the Millipede deposit. Near the playa inlet salinity levels exceeding 57,000 mg/L occur just below the water table, increasing to over 95,000 mg/L at 2 m below the water table.

Although the international literature on subterranean fauna typically records stygofauna as being restricted to freshwater, and occasionally brackish water, there is abundant Australian literature to show that in Western Australia at least stygofauna occur within a wide range of groundwater salinities. Moreover, studies in Western Australia have demonstrated that taxa typically considered as fresh water organisms (e.g. the Bathynellacea) may occur in close association with near-marine lineages. The apparent tolerance of subterranean fauna in the WA goldfields region to a wide range of salinities has been specifically noted at Lake Way (Humphreys, 2008).

In baseline studies conducted for the Wiluna Uranium Project and its Extension, there has been no clear evidence of a relationship between groundwater salinity and either subterranean fauna abundance or diversity (Figure 12.11 and Figure 12.12).

Figure 12.11: Stygofauna abundance vs groundwater conductivity - Hinkler Well calcrete (2009/2010)

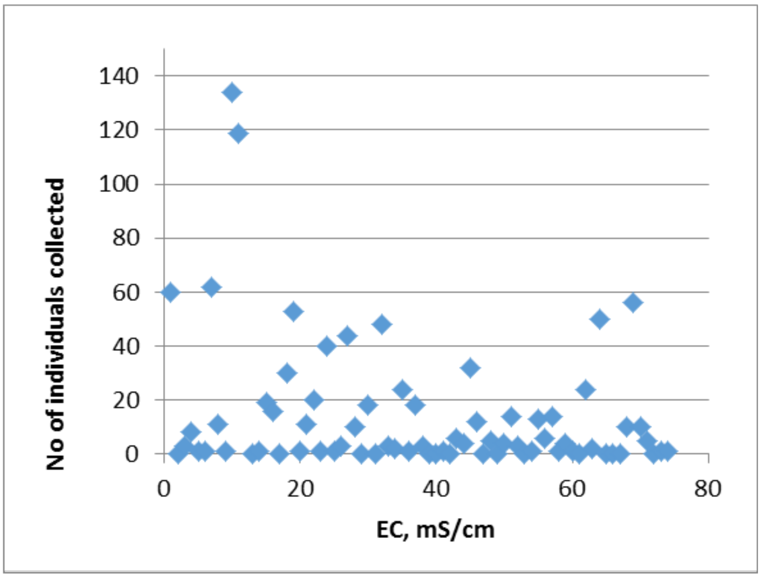
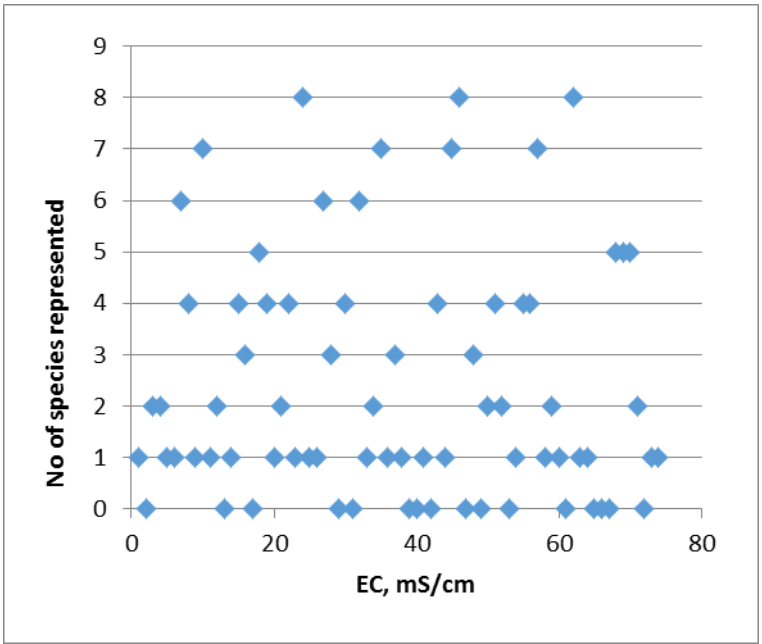


Figure 12.12: Stygofauna diversity vs groundwater conductivity - Hinkler Well calcrete (2009/2010)



12.5.2 Hinkler Well Calcrete Stygofauna Assemblage

Diversity

The Millipede 2015 targeted survey collected at least 13 species from six higher level taxonomic groups, Amphipoda, Bathynellacea, Coleoptera, Cyclopoida and Harpacticoida copepods, and Oligochaeta (MWH 2015 – Appendix 10.11) and Table 12.5.

The collection of the amphipod species, *Chiltoniidae*-SAM6, and the copepod, Parapseudoletomesochra sp. TK2 (previously known only from the Lake Violet calcrete), represent new species records for the Hinkler Well calcrete.

In total, 34 species have been recorded from the Hinkler Well calcrete stygofauna assemblage (Table 12.5). This includes four species known from published records that have not been collected as part of the Millipede targeted survey or the Level 2 baseline Centipede assessment (MWH 2015 – Appendix 10.11, Outback Ecology 2012a – Appendix 10.26).

The diversity of the Hinkler Well calcrete stygofauna assemblage is comparable to the species richness of other well studied Lake Way and Lake Maitland calcrete systems (Barwidgee 28 species; Lake Violet 35 species; Uramurdah 36 species), but considerably less than recorded for the Yeelirrie calcrete systems with 70 species recorded (Outback Ecology 2012a - Appendix 10.26; Subterranean Ecology 2010). Although the larger sample effort conducted for the Yeelirrie survey would have contributed to the richer fauna recorded, another factor involved would have been the greater degree of geographic structuring of species evolution as a result of the Yeelirrie calcretes not representing as homogenous and interconnected systems compared to the broader deltaic Lake Way and Lake Maitland systems.

Distributions

The distributions of the stygofauna species recorded from the targeted survey are consistent with the geological and hydrogeological assessments of the area which indicated that the part of the proposed Millipede mining area forms a connected habitat extension of the broader Hinkler Well calcrete delta.

Of the 13 stygofauna species collected in the 2015 targeted survey, eight were from within the proposed Millipede pit area (MWH, 2015 – Appendix 10.11). Seven of the eight species, Atopobathynella wattsi, *Enchytraeidae*-OES20, Fierscyclops fiersi, *Halicyclops* eberhardi, *Nitokra* sp. TK1, *Nitokra* sp. TK2, and *Schizopera* sp. TK7, were recorded either as part of the targeted survey, or from previous surveys or published studies from other locations within the Hinkler Well calcrete outside the proposed pit boundary (Table 12.5). The amphipod *Chiltoniidae*-SAM6 that had not been recorded previously, was the only stygofauna species not found from beyond the proposed Millipede pit boundary.

Figures showing the locations where species were collected are in MWH 2015 – Appendix 10.11.

Amphipoda

The amphipod species, *Chiltoniidae*-SAM6, has been collected from two bores within the proposed Millipede pit area only. Additional *Chiltoniidae* specimens were collected from Millipede, but DNA sequencing was unsuccessful, so these species remain indeterminate. The seemingly restricted distribution of *Chiltoniidae*-SAM6 to within the proposed mine pit impact means this species is of potential conservation concern.

Table 12.5: Stygofauna diversity and distributions at Millipede – 2015 targeted survey[1]

Taxon	Total Abundance	Impact			Non-Impact	Occur Outside Project Survey Area
		Mining Area		> 0.5 m Drawdown	< 0.5 m Drawdown	
		Millipede	Centipede			
Amphipoda						
Chiltoniidae						
Chiltoniidae-SAM3	8		√			
Chiltoniidae-SAM5	7				√	
Chiltoniidae-SAM6	51	√				
Chiltoniidae indet.	6	√				
Bathynellacea						
Parabathynellidae						
Atopobathynella wattsi	4	√				√
Coleoptera						
Dytiscidae						
Limbodessus hinkleri	19		√	√	√	
Copepoda: Cyclopoida						
Cyclopidae						
Fierscyclops fiersi	350	√		√		√
Halicyclops eberhardi	285	√	√	√	√	√
Copepoda: Harpacticoida						
Ameiridae						
Nitokra-TK1	3	√	√	√		√
Nitokra-TK2	13	√	√			√
Parapseudoleptomesochra-TK2	1		√			√
Miraciidae						
Schizopera-TK7	3	√	√	√		
Oligochaeta						
Enchytraeidae-OES20	6	√			√	
Phreodrilidae-OES21	3			√	√	

Note: 1. Recorded from the 2015 targeted survey. Identified species and morphospecies shaded in purple represent new records for Hinkler Well calcrete.

Bathynellacea

The parabathynellid Atopobathynella wattsi has been shown from published records to have a relatively widespread distribution. Atopobathynella wattsi was first described from material collected from the Lake Violet calcrete and Millbillillie Calcrete, more than 20 and 75 km respectively to the north of the proposed Millipede mining area (Cho *et al.* 2006). Later genetic analysis included material from the Hinkler Well calcrete (Guzik *et al.* 2008). Earlier surveys recorded this species from the eastern delta region of the Hinkler Well calcrete within the proposed Centipede mining area, as well as outside the mining areas within the modelled 1 m groundwater drawdown contour (Outback Ecology 2011h - Appendix 10.64, Outback Ecology 2012a - Appendix 10.26). The broader distribution of Atopobathynella wattsi beyond the proposed mining impact areas means this species is not of conservation concern in relation to the proposed Millipede and Centipede developments.

Copepoda

Of the five copepod species collected from the Millipede resource area, four species (Fierscyclops fiersi, *Halicyclops* eberhardi, *Nitokra* sp. TK1, and *Nitokra* sp. TK2), have widespread distributions that extend well beyond the proposed Millipede and Centipede development impact areas. These four species were collected from other Lake Way associated calcretes (Lake Violet and/or Uramurdah), and, in case of *Halicyclops eberhardi*, from Barwidgee calcrete associated with Lake Maitland (Outback Ecology 2012c - Appendix 10.28, Outback Ecology 2012a - Appendix 10.26).

Fierscyclops fiersi has been widely recorded within the Yilgarn region including locations outside the Carey Paleodrainage channel (Karanovic 2004). Within the Hinkler Well calcrete system, *Fierscyclops fiersi* has been collected further west of Millipede outside the proposed pit boundary, but within the modelled 1 m groundwater drawdown contour.

Halicyclops eberhardi has also been widely recorded from aquifers within the Yilgarn region (Karanovic 2004, 2007a, b, 2009). Within the Hinkler Well calcrete system, *Halicyclops eberhardi* has been commonly collected within the calcrete delta area from within both proposed Millipede and Centipede mine pits, as well as from within the modelled 1 m groundwater drawdown contour. In addition, the species distribution extends beyond the delta area over the Erawalla Fault uplift to the western portion of the Hinkler Well calcrete system.

Within the Hinkler Well calcrete, both *Nitokra* sp. TK1 and *Nitokra* sp. TK2 were commonly collected from the delta area within both proposed mine pits as well as from within the modelled 1 m groundwater drawdown contour. Although both species were not collected from beyond the modelled 0.5 m groundwater drawdown contour (i.e. non-impact area) within the Hinkler Well calcrete, *Nitokra* sp. TK1 was collected from the Uramurdah calcrete and *Nitokra* sp. TK2 was collected from both the Lake Violet and Uramurdah calcretes (Outback Ecology 2011h - Appendix 10.64, Outback Ecology 2012a - Appendix 10.26). Both species are not considered to be of conservation concern

The distribution of *Schizopera* sp. TK7 was expanded by the targeted survey with specimens collected from the Millipede resource area as well as further west along the Hinkler Well calcrete beyond the proposed mining areas, but within the modelled 1 m groundwater drawdown zone. Previously, *Schizopera* sp. TK7 had only been recorded from within the proposed Centipede pit boundary and was one of three species of potential conservation concern due to proposed mining excavation (Outback Ecology 2011h - Appendix 10.64; Outback Ecology 2012a - Appendix 10.26). The risk assessment conducted concluded that *Schizopera* sp. TK7 was not at risk by the implementation of the Project due to the greater extent of suitable habitat outside the proposed impact zone. This is indicated by the broader distribution of sympatric species including other *Schizopera* species, as well as by geological and hydrogeological assessments. The broader distribution of *Schizopera* sp. TK7 demonstrated by the 2015 targeted survey highlights the previous vagaries faced in assessing a species distribution from only a few records, but also confirms the usefulness of biological surrogates (e.g. sympatric and/or closely related species) and physical surrogates (e.g. habitat from geology, hydrogeology and groundwater physicochemical attributes) to assess likely distributions. The recent collection of *Schizopera* sp. TK7 from beyond the Centipede deposit provides further confirmation that the copepod species is more broadly distributed within and around the Hinkler Well calcrete and not confined to the proposed deposit areas only. This species, along with the other four broadly distributed copepod species recorded from the Millipede deposit, are not considered to be species of conservation concern in relation to the proposed Millipede and Centipede developments.

Table 12.6: Stygofauna diversity and distributions recorded from 2007 to 2015 surveys Millipede-Centipede[1]

Millipede/Centipede Project Survey Area Taxa	Total Abundance	Impact			Non-Imapct	Occur Outside Project Survey Area
		Mining Area		> 0.5 m Drawdown	< 0.5 m Drawdown	
		Millipede	Centipede			
Amphipoda						
Chiltoniidae sp. SAM3	141		√	√	√	
Chiltoniidae sp. ?SAM3	2			√		
Chiltoniidae sp. SAM5	7				√	
Chiltoniidae sp. SAM6	51	√				
Bathynellacea						
Bathynellidae	1			√	◆	
Atopobathynella wattsi	645	√		√		◆
Atopobathynella ?wattsi	4		√	√		
Atopobathynella sp. OES5	51				√	
Brevisomabathynella sp. SAM2	20		√			
Coleoptera						
Limbodessus hinkleri	134		√	√	√ ◆	
Limbodessus ?hinkleri	1			√		
Limbodessus macrohinkleri	2			√	◆	
Limbodessus raeae					◆	
Copepoda: Cyclopoida						
Dussartcyclops uniarticulatus	5		√		√	√ ◆
Fierscyclops fiersi	434	√		√		√ ◆
Halicyclops ambiguus				◆		√ ◆
Halicyclops eberhardi	539	√	√	√	√ ◆	√ ◆
Halicyclops kieferi	2				√	√ ◆
Metacyclops laurentiisae	300			√	√ ◆	√ ◆
Copepoda: Harpacticoida						
Ameiropsyllus sp. TK1	4		√			√
Australocamptus similis	6			√		√
Haifameira pori					◆	√
Kinnecaris lakewayi	16				√	√ ◆
Nitokra lacustris pacifica	1			√		√
Nitokra sp. TK1	29	√	√	√		√
Nitokra sp. TK2	32	√	√			√
Parapseudoleptomesochra sp. TK1	14			√		√
Parapseudoleptomesochra sp. TK2	1		√			√
Parapseudoleptomesochra karamani					◆	√ ◆
Schizopera austindownsi	31		√	√	√	√ ◆
Schizopera uramurdahi	27		√	√	√	√ ◆
Schizopera sp. TK4	1		√			
Schizopera sp. TK7	22	√	√	√		
Schizopera sp. TK10	2			√		
Oligochaeta						
Enchytraeidae-OES20	21	√			√	
Naididae indet.	1		√			
Phreodrilidae-OES21	8			√	√	
Ostracoda						
Candonopsis (Abcandonopsis) linnaei	16		√		√	
Candonopsis sp. IK2	1			√	√	

Notes: 1. (Taxon occurrences from published records are also included (◆) Identified species and morphospecies shaded in: orange, found in Millipede mining area only; green, found in Centipede mining area only; yellow, found within groundwater drawdown > 0.5m.

Oligochaeta

The distribution of the oligochaete *Enchytraeidae*-OES20 is widespread within the Hinkler Well calcrete occurring from the western portion of the Hinkler Well Calcrete through to the eastern delta area within the proposed Millipede pit. The relatively broad distribution of this species is consistent with findings from other studies in the Goldfields, Pilbara, and Kimberley regions (Outback Ecology 2013a, 2014, Subterranean Ecology 2008). Genetic analysis of enchytraeids from non-calcrete habitat bordering Lake Austin revealed a relatively diverse assemblage with a number of the species present possessing relatively widespread distributions, one of which was recorded from the north of Lake Austin as well from the south indicating that the hypersaline conditions of the salt lake did not pose a barrier to dispersal (Leijs and King (2013) in (Outback Ecology 2013a).

The taxonomy and ecology of the *Enchytraeidae* is poorly known, with no stygal species described to date (Pinder 2009, Pinder 2007). These worms are commonly recorded in subterranean fauna surveys, and occur in both surface and subterranean aquatic systems (freshwater and marine), or semi-aquatic and terrestrial habitats (Outback Ecology 2014, Rota *et al.* 2007, van Vliet *et al.* 1997). It is not known categorically whether *Enchytraeidae*-OES20 is strictly an aquatic (inhabiting the aquifer), semi-aquatic or terrestrial oligochaete species. Terrestrial invertebrate fauna are often collected in stygofauna nets having either being dislodged from the soil profile during retrieval of the nets or collected from the water column into which they may have fallen (Outback Ecology 2011i, Outback Ecology 2012c - Appendix 10.28, Outback Ecology 2013a, Outback Ecology 2013b, Subterranean Ecology 2008). Some *Enchytraeidae* species have been demonstrated to not be obligate groundwater inhabitants, with genetic data showing material collected in troglofauna traps were conspecific (same species) with material collected from stygofauna net hauls (Leijs 2013, Outback Ecology 2011i). However, no *Enchytraeidae*-OES20 material was collected from the relatively substantial trapping effort conducted. It is for this reason that *Enchytraeidae* OES20 is considered a putative stygofauna species, but not of conservation concern.

12.5.3 Hinkler Well Troglofauna Assemblage

Diversity

The Millipede 2015 targeted survey collected three troglofauna species from three higher level taxonomic orders, Diplopoda, Isopoda and Pseudoscorpionida (MWH 2015 – Appendix 10.11) and are shown at Table 12.7.

Two species, the polyzenid pincushion millipede, *Lophoproctidae*-OES1, and the pseudoscorpion *Tyrannochthonius*-OES3, were collected within the proposed Millipede pit. All three troglofauna species have been collected in previous surveys of the Hinkler Well calcrete (Outback Ecology 2011h - Appendix 10.64).

In total, 9 species have been recorded from the Hinkler Well calcrete troglofauna assemblage (Table 12-9). The diversity of the Hinkler Well calcrete troglofauna assemblage is comparable to the species richness of other well studied Lake Way and Lake Maitland calcrete systems (Barwidgee 9 species; Uramurdah 9 species) but considerably less than recorded for the Yeelirrie calcrete systems with 45 species recorded from the broader area (Outback Ecology 2012a - Appendix 10.26).

Figures showing the locations of the species recorded are in Appendix 10.11.

Table 12.7: Troglofauna diversity and distributions – Millipede 2015 targeted survey

Taxon	Total Abundance	Impact			Non-Impact
		Mining Area		> 0.5 m Drawdown	< 0.5 m Drawdown
		Millipede	Centipede		
Diplopoda: Polyxenida					
Lophoproctidae-OES1	1	√			
Isopoda					
Scyphacidae					
Haloniscus sp. OES3	2		√		
Pseudoscorpionida					
Chthoniidae					
Tyrannochthonius sp. OES3	1	√			

Table 12.8: Troglofauna diversity and distributions – Millipede-Centipede 2007 to 2015 surveys[1]

Taxon	Total Abundance	Impact			Non-Impact	Occur Outside Project Survey Area
		Mining Area		> 0.5 m Drawdown	< 0.5 m Drawdown	
		Millipede	Centipede			
Diplopoda: Polyxenida						
Lophoproctidae-OES1	3	√		√		√
Diplura						
Projapygidae	1		√			
Isopoda						
Scyphacidae						
Haloniscus sp. OES3	135		√			
Haloniscus sp. OES9	1		√			
Haloniscus sp. OES10	8		√			
Haloniscus indet.	7	√	√	√		
Pauropoda						
Pauropodina	2		√		√	
Pseudoscorpionida						
Chthoniidae						
Tyrannochthonius sp. OES3	19	√	√	√		
Symphyla						
Symphyla	1			√		
Zygentoma						
Nicoletiidae						
Trinemura	2				√	

Notes: 1. Identified species and morphspecies shaded in: green have only been found in the Centipede mining area and were previously assessed (EPA Assessment 1819 and EPBC 2009/5174); yellow, found within groundwater drawdown > 0.5 m.

Distribution

The distributions of the troglofauna species recorded from the targeted survey are consistent with the geological assessments of the area that indicated that part of the proposed Millipede mining area forms a connected habitat extension of the broader Hinkler Well calcrete delta. The distributions of the only troglofauna species recorded from within the proposed Millipede pit, *Lophoproctidae*-OES1, and *Tyrannochthonius* sp. OES3, both extend beyond the proposed pit boundary.

Lophoproctidae-OES1 is considered conspecific with *Polyxenid* material from Lake Violet and Uramurdah calcretes (previously designated as *Polyxenid* sp. OES1 in Outback Ecology (2011h - Appendix 10.64) and is unlikely to be a be short range endemic (SRE) as genetic analysis indicated sequenced specimens were part of a widespread species whose distribution extended to the Pilbara (Leijs *et al.* (2012) (Appendix E) reported in Outback Ecology (2012a - Appendix 10.26)). Another widespread species whose distribution was also demonstrated by genetic analysis to extend from the Goldfields to the Pilbara was found to be closely related to *Lophoproctidae*-OES1 (Leijs and King (2013) in Outback Ecology (2013a)). Both *Polyxenid* species are more likely to be troglophiles and not troglobitic. Within the Hinkler Well calcrete, *Lophoproctidae*-OES1 has been recorded from within the modelled 1 m groundwater drawdown contour and the proposed Millipede pit boundary only. However, the broader distribution of *Lophoproctidae*-OES1 beyond the Hinkler Well calcrete means this species is not of conservation concern in relation to the proposed Millipede and Centipede developments.

Tyrannochthonius-OES3 has been relatively commonly collected from the Hinkler Well calcrete delta region which has been more intensively sampled than the western calcrete portion. Genetic analysis confirmed that *Tyrannochthonius*-OES3 was a separate species to *Tyrannochthonius* material collected from Lake Violet, Uramurdah and Barwidgee calcrete areas and indicated that each calcrete hosted an SRE pseudoscorpion species (Leijs (2011b) in Outback Ecology (2012e). This strong geographic pattern indicative of short range endemism within *Tyrannochthonius* in Western Australia was further illustrated by Harrison et al. (2014) that also included material from Lake Violet and Uramurdah calcretes.

Tyrannochthonius-OES3 was previously considered a species of potential conservation concern as it had not been collected from outside the modelled 1 m groundwater drawdown contour associated with the development of the Centipede mining area (Outback Ecology 2011h - Appendix 10.64). The risk assessment conducted concluded that *Tyrannochthonius*-OES3 was not at risk by the implementation of the Project due to the greater extent of suitable habitat present outside the proposed impact zone as well as the extent of suitable habitat that would remain for troglofauna within the modelled groundwater drawdown contours. The recent collection of *Tyrannochthonius*-OES3 from the Millipede deposit provides further confirmation that the pseudoscorpion species is more broadly distributed within and around the Hinkler Well calcrete and not confined to the proposed deposit areas only. This species is not considered here to be a species of conservation concern.

12.5.4 Barwidgee Calcrete Stygofauna Assemblage

Diversity

In total, 28 stygofauna species from eight higher level taxonomic groups, Amphipoda, Bathynellacea, Coleoptera, Cyclopoida and Harpacticoida copepods, Isopoda, Oligochaeta and Ostracoda, have been recorded in surveys and published records from the Barwidgee calcrete (Outback Ecology 2012c – Appendix 10.28). Table 12.9 details the results.

The diversity of the Barwidgee calcrete stygofauna assemblage is comparable to the species richness of the well studied Lake Way calcrete systems (Hinkler Well 34 species; Lake Violet 35 species; Uramurdah 36 species) but considerably less than recorded for the Yeelirrie calcrete systems with 70 species recorded (Outback Ecology 2012a - Appendix 10.26).

Distribution

Of the 28 species collected, no species were found to be confined to the proposed borefield's modelled 0.5 m drawdown contour. Two species were not recorded outside of the area to be affected by mining, as follows:

- *Chiltoniidae* sp. SAM4 – not recorded outside the mining operations resource area; and
- *Schzopera* sp. TK1 – not recorded outside the mining operations resource area.

Chiltoniidae sp. SAM4 is known from three specimens collected during the March 2010 survey from one bore only. The probable reason for this low level of collection is the low population number existing within the bore (Outback Ecology 2012c – Appendix 10.28).

Assessment of other Chiltoniidae species found that they can tolerate hypersaline environments (in which Chiltoniidae sp. SAM4 was found), but they prefer lower levels of salinity. In the bore where Chiltoniidae sp. SAM4 was found, four other species were also collected. These species were also collected in bores outside the mining impact areas. The extent of collection of these species indicates that there is a contiguous habitable saturated geology that extends outside the impact area and it is likely that the Chiltoniidae sp. SAM4 exists within this habitat (MWH, 2015 – Appendix 10.11).

Schizopera sp. TK1 has been collected sympatrically with seven other species. The distributions of these species extend beyond the mining impact area and further west up the Barwidgee calcrete in less saline waters (Outback Ecology 2012c – Appendix 10.28). The broader distributions and habitat preferences of these sympatric species indicate that suitable habitat for Schzopera sp. TK1 exists elsewhere in the calcrete and outside the proposed mining areas.

Haloniscus sp. OES1 was originally considered in the baseline survey EIA (Outback Ecology 2012c – Appendix 10.28) to be a species of conservation concern because it had not been recorded outside the 0.5 m groundwater drawdown contour. However, Toro's proposed modifications in mining the Lake Maitland deposit and the subsequent reduction in lateral extent of groundwater drawdown impact, this species is now not restricted to the proposed groundwater drawdown impact zone only.

The locations of the sympatric species described above are shown in Appendix 10.28.

Table 12.9: Stygofauna species diversity, abundance and distribution – Lake Maitland[1]

Taxa	Abundance	Regional Distribution	LMUP Non-impact	LMUP Impact: Mining operations area: > 0.5 m Drawdown	LMUP Impact: Mining operations area: Resource	LMUP Impact: Borefield: > 0.5 m Drawdown
Amphipoda: Chiltoniidae						
Chiltoniidae^	44		√	√		
Chiltoniidae sp. OES1*	45		√	√		
Chiltoniidae sp. SAM4*	3				√	
Bathynellacea: Parabathynellidae						
Atopobathynella	1				√	
Atopobathynella sp. OES6*	2		√			
Bathynellidae						
Bathynellidae^	2		√			
Bathynellidae sp. OES1	1		√			
Coleoptera: Dytiscidae						
Limbodessus barwidgeensis^	2		√			
Limbodessus usitatus #			√			
Copepoda: Cyclopoida: Cyclopidae						
Halicyclops eberhardi	2	H, LV, Ur,			√	
Halicyclops sp. TK1	110		√	√	√	
Halicyclops sp. TK2	279		√	√	√	
Halicyclops sp. TK3	9		√			
Mesocyclops brooksi	2	WS	√			
Microcyclops varicans	3	WS	√			
Harpacticoida: Ameiridae						
Ameiropsyllus sp. TK1	1	H			√	
Nitokra lacustris pacifica	10	WS	√		√	
Nitokra sp. TK3	16		√		√	
Canthocamptidae						
Australocamptus similis	5	H, LV				√
Parastenocarididae						
Kinnecaris sp. TK3	52		√			
Miraciidae						
Schizopera sp. TK1	7				√	
Schizopera sp. TK5	9		√	√		
Schizopera sp. TK6	53		√	√		
Schizopera sp. TK8	12		√	√		
Isopoda: Scyphacidae						
Haloniscus sp. OES1	15			√	√	
Oligochaeta: Enchytraeidae						
Enchytraeidae sp. OES1	52		√			√
Enchytraeidae sp. OES2	35		√			√
Naididae						
Naididae sp. OES1	2		√			
Naididae sp. OES2	20		√		√	
Ostracoda: Podocopida: Candonidae						
Candonopsis dani	38	LV	√	√		
Candonopsis sp. IK2	2		√			

Notes: 1. Identified species and morphospecies: shaded in orange found to date in resource area only; shaded in yellow, found within groundwater drawdown > 0.5 m.
H= Hinkler Well calcrete; LV= Lake Violet calcrete; Ur= Uramurdah calcrete; WS= widespread in region.
** Included in DNA analysis (Appendix I); ^ DNA analysis results pending; # Not collected in this study.*

12.5.5 Barwidgee Calcrete Troglofauna Assemblage

Diversity

A total of nine troglofauna species representing five higher taxonomic levels, Chilopoda, Hemiptera, Isopoda, *Pauropoda* and Pseaudoscorpionida, were recorded from the Barwidgee calcrete (Outback Ecology 2012b – Appendix 10.27). Table 12.10 details the results.

No species were found in the upper tributary catchment area to the north of Lake Maitland associated with the proposed borefield, which is characterised by weathered basement geologies of the Yandal greenstone belt. The diversity of the Barwidgee calcrete troglofauna assemblage is comparable to the species richness of the well studied Lake Way calcrete systems (Hinkler Well 9 species; Uramurdah 9 species) but considerably less than recorded for the Yeelirrie calcrete systems with 45 species recorded from the broader area (Outback Ecology 2012a - Appendix 10.26).

Table 12.10: Troglofauna species diversity, abundance and distribution – Lake Maitland[1]

Taxon	Total abundance	Non-impact	Impact		
			Mining operations area		Northern Borefield
			Groundwater drawdown	Resource	
Chilopoda					
Scolopendridae sp. OES1	1			1	
Hemiptera					
Meenoplidae ^	3	3			
Isopoda					
Scyphacidae					
Haloniscus sp. OES12 *****	41		37	4	
Haloniscus sp. OES14 *****	22		22		
Platyarthiridae					
Trichorhina sp. OES6 *	95	6	72	17	
Pauropoda					
Pauropodina	2		2		
Pseudoscorpionida					
Chthoniidae					
Tyrannochthonius indet.	1		1		
Tyrannochthonius sp. OES4 *	4	3	1		
Tyrannochthonius sp. OES5 *	1		1		
Tyrannochthonius sp. OES6 ^	1	1			

Notes: 1. Species restricted to resource area shaded in orange.
** Included in DNA analysis (Appendix F), ^ DNA analysis results pending.*

Distribution

Of the nine species recorded, only one species *Scolopendridae* sp. OES 1, was found to be restricted to within the proposed mining pit area. Four other species *Haloniscus* sp. OES12, *Haloniscus* sp. OES14, *Pauropoda* sp., and *Tyrannochthonius* sp. OES5 were restricted to within the 2.0 m to 0.5 m drawdown areas.

Scolopendridae was found within the mining area only with a single specimen recovered. This is likely to be caused by low population numbers rather than the actual distribution being limited to one bore (Outback Ecology, 2012b – Appendix 10.27). As the Barwidgee calcrete habitat extends away from the mining area for 10 km west, it is likely that suitable habitat for the species will exist beyond the mining area. This is demonstrated by the distribution of other troglofauna species throughout the calcrete (Outback Ecology, 2012b – Appendix 10.27).

The other four species were all found outside the mining area, but within the groundwater drawdown to result from mine dewatering.

Figures showing the locations of the species recorded are in Appendix 10.27.

12.6 Potential Impacts

The two main impacts to subterranean fauna communities and populations from implementation of the Proposal would be loss of habitat due to dewatering and mining. Direct removal of portions of geological formations inhabited by subterranean fauna would occur as a part of mining the ore body. Associated mine dewatering would lower the water table and reduce the amount of saturated (or humid) subsurface environment available for subterranean fauna habitation. The removal of habitat through mining excavation poses the greater risk to the conservation of stygofauna and troglofauna.

12.6.1 Direct Impacts

Direct impacts of mining at Millipede/Centipede (including mining previously approved under Ministerial Statement 913) and at Lake Maitland are estimated to impact 0.76% and 2.9% of the Hinkler Well and Barwidgee stygofauna PECs, respectively, and are shown in Table 12.11 and Table 12.12.

12.6.2 Indirect Impacts

Groundwater Drawdown

Throughout the following discussion it has been assumed that the proposed low permeable water barriers erected in the mine pits are ineffective, that is to say, a worst case assumption.

There are no universally accepted rules about what amount of groundwater drawdown is likely to result in an adverse impact on subterranean fauna. Recent research suggests that there is not a simple relationship between the degree of saturation in an aquifer and the survival of different stygofauna taxa (Stumpp and Hose, 2013). Groundwater drawdowns are considered more likely to have adverse impacts on stygofauna than on troglofauna. This is because lowering of the groundwater table can directly reduce the extent of habitat available for stygofauna, which are aquatic organisms. In the case of troglofauna, the lowering of the water table could mean that portions of saturated geology containing suitable habitable voids will become unsaturated and potentially available for colonisation by troglofauna.

Although troglofauna are not aquatic organisms, it is thought that they can be affected in some measure by changes in subsurface humidity. Troglofauna are considered to represent relictual fauna related to surface dwelling groups which have evolved to be obligate inhabitants of subterranean environments of a sufficiently high humidity that would otherwise render them uninhabitable.

In Western Australia, it has generally been assumed that subterranean fauna habitat values can be maintained by limiting groundwater drawdown to an amount that is not significantly different to the naturally occurring year-to-year variability in water levels or by maintaining the saturated thickness of the aquifer at approximately 70% of the pre-mining saturated thickness, ensuring habitable geologies remain saturated. Toro has used a nominal 0.5 m groundwater drawdown level as the indicator of the minimum amount of change likely to result in discernible impacts on subterranean fauna habitats as natural groundwater variations in the Wiluna Project area were demonstrated to commonly range from ±0.1 to 0.3 m SWL, with less common variations occurring in the range of ±0.6 to 1.26 m SWL (Outback Ecology 2012a - Appendix 10.26).

The potential extent of the subterranean fauna habitat impacted by the proposed mining and associated groundwater drawdowns for Millipede (including within the previously approved Centipede footprint) and Lake Maitland developments, calculated as a percentage of the Hinkler Well and Barwidgee stygofauna PEC areas impacted, are 6.0% and 13.4%, respectively. Refer to Table 12.11 and Table 12.12.

Table 12.11: Potential extent of subterranean fauna habitat impacted for Lake Way associated calcrete stygofauna PECs

Lake Way associated calcrete stygofauna PECs	Extent (ha)	Centipede mining Area impact, ha	Millipede mining Area impact, ha	Centipede and Millipede mining groundwater drawdown impact, ha	Lake Way Mining Area Impact, ha	Lake Way Mining groundwater drawdown impact, ha	West Creek Borefield groundwater drawdown impact, ha	Combined Groundwater drawdown and mining area direct impact (% of PEC)	Mining Area impact only (% of PEC)
Hinkler Well	22052.75	19.3	149.0	1328.0				6.0%	0.8%
Lake Violet	10126.77						154.9	1.5%	
Lake Way South	8219.92								
Millbillillie Bubble Well	10031.67								
Uramurdah	8224.27				23.5	794.9		10.0%	0.3%
Wiluna BF	2873.73								

Groundwater Quality

Toro proposes to reinject surplus water from dewatering of mine pits at Lake Maitland. The strategy that has been proposed is to avoid clearing of land for the construction of evaporation ponds or (alternatively) discharging of surplus water from mine dewatering, as currently happens at some other Western Australian mining operations in the Goldfields region. The reinjection of hypersaline water into fresh water systems has the potential to cause local increases in the salinity of shallow groundwater, which could reduce the suitability of the shallow aquifer for some subterranean fauna.

Hinkler Well Calcrete: Potential Impacts on Subterranean Fauna Habitat

The shallow and relatively broad Millipede and Centipede ore deposits would be mined by open pit methods primarily using surface miners as well as conventional excavators for mining the non-mineralised overburden (Toro Energy, 2011a). The proposed mine disturbance area at the Millipede and Centipede deposits would cover approximately 928 ha (Millipede 538 ha; Centipede 390 ha). The depth of mining is likely to be between 5 m and 15 m below the ground surface with most of the mining not exceeding 10 m in depth. As the groundwater levels in the proposed mining areas vary from 0.5 m bgl to 5 m bgl below the ground surface, dewatering will be required to provide dry mining conditions.

The proposed Millipede and Centipede mining areas are situated along the eastern boundary of the Hinkler Well calcrete system bordering the Lake Way playa. The Hinkler Well calcrete stretches in an east to west orientation as a relatively narrow band, 2–3 km wide, for 35 km along the Abercromby palaeochannel, comprising an area greater than 80 sq km.

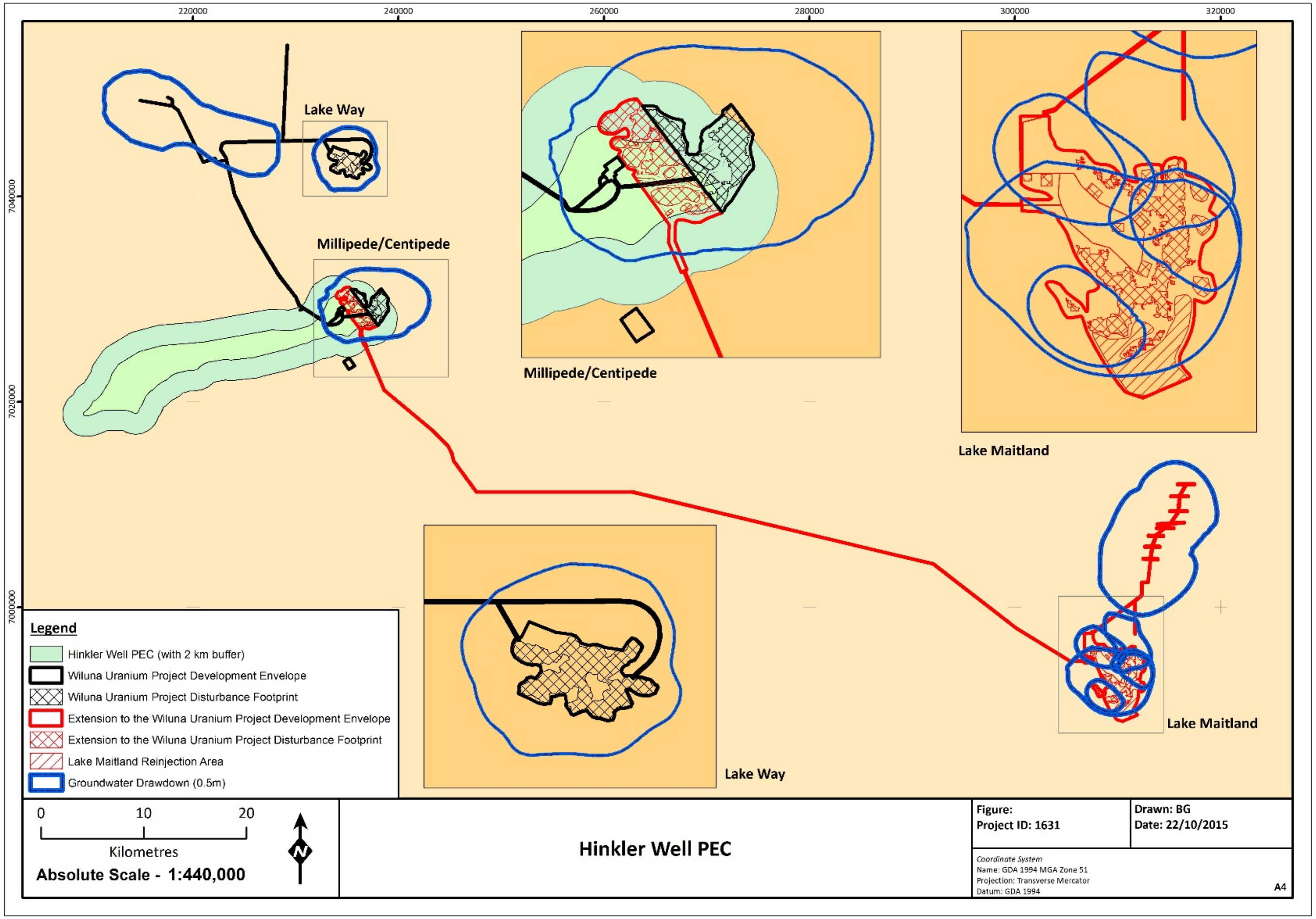
The thickness of the Hinkler Well calcrete is reported to vary from 10 m to 40 m (Dundon 1997). In the vicinity of Hinkler Well, the calcrete profile ranged from 16 m to 23 m thick with 34 m recorded further west (Aquaterra 2010d). Moving eastwards, the calcrete thins near the Goldfields Highway where it is constrained by the elevation of the bedrock in association with the Erawalla Fault. East of the Erawalla Fault the calcrete fans out and broadens in profile varying from 5 m to 19 m thick between the Goldfields Highway and Abercromby Well. In the eastern extent of the calcrete between Abercromby Well and the Lake Way playa, the calcrete thickness was between 0.5 m to 24 m (average 8.1 m) (Aquaterra 2010d). Bore lithologies in the delta area bordering the lake playa indicated the calcrete to be 0.7 m to 1.5 m below the ground surface and to be approximately 2 m to 3 m thick.

The standing groundwater water depths across the Hinkler Well calcrete vary from 0.8 m to 7.8 m (average 3.1 m) below the ground surface, indicating that a considerable portion of the calcrete is saturated. In the proposed Millipede/Centipede mining areas, along the flood plain fringing the lake playa, standing water levels were 0.8 m to 2.95 m (average 1.57 m).

The maximum lateral extent of the modelled 0.5m groundwater drawdown contour resulting from dewatering during mining at Millipede/Centipede (assuming failure of water barriers) would extend approximately 2.8 km to the west of the Millipede/Centipede mining area and approximately 4 km to the east of mine. (RPS 2015b – Appendix 10.56).

The area of Hinkler Well PEC to be directly impacted by mining excavation for the Wiluna Extension Project (not including groundwater drawdowns) would be approximately 149 ha, equivalent to about 0.68% percent of the known extent of the Hinkler Well PEC. The extent of the modelled 0.5 m groundwater drawdown associated with the development of the combined Millipede and Centipede deposits would be approximately 1328 ha (Figure 12.13). This is substantially the same as the extent of groundwater drawdown previously modelled for dewatering of the Centipede deposit. In all, the extent of the Hinkler Well PEC affected by the combined direct and indirect impacts of the approved Wiluna Uranium Project, together with the proposed Extension, is approximately 1328 ha, which is approximately 6.0% of the estimated extent of the Hinkler Well PEC.

Figure 12.13: Subterranean PECs – Millipede/Centipede



The in-pit storage of tailings at Millipede could, in principle, result in impacts to subterranean fauna if a significant undetected loss of containment were to occur, allowing ongoing, long-term loss of tailings leachate to groundwater. The TSF would have a clay base and compacted walls. Modelling of the permeability of the TSF walls was undertaken during EPA Assessment 1819 and it was determined that the TSF walls were of low permeability and posed no environmental risk. Toro plans to construct the TSF at Millipede in the same manner and has therefore drawn the same conclusion.

In addition to the construction of the TSF walls, Toro would also leave the water barrier in place around the proposed TSF. This would act as a secondary safeguard against leaching and further prevent the escape of contaminants into the environment. CSIRO modelling does not show any changes to groundwater quality beyond the predicted 0.5 m draw down.

From recent upgrades to the contaminant fate transport model (discussed in Section 16), it has been observed that the lake sediments at Lake Way would act as a chemical trap for any mobilised contaminants and prevent their spread downstream. Toro has agreed with the DER that this needs to be further demonstrated, and this would be done prior to the submission of the Mining Proposal for the Wiluna Uranium Project.

Hinkler Well Calcrete: Potential Impacts on Conservation Significant Subterranean Fauna

The removal of habitat through mining excavation poses a conservation risk to one of the eight stygofauna species recorded from within the proposed Millipede pit boundary.

The amphipod, *Chiltoniidae*-SAM6, was recorded from two Millipede bores only. This taxon had not been recorded previously in Toro's investigations and was the only stygofauna species not to have been found from beyond the proposed Millipede pit boundary. No other species of stygofauna or troglofauna were considered of conservation concern in the context of the proposed Extension of the Wiluna Uranium Project as all species, except *Chiltoniidae*-SAM6, were found to occur beyond the proposed pit boundary.

It is not possible to define the distribution range of stygofauna species that are known from only one or two bores. The seemingly restricted distribution of a species to a single bore is likely to be an artefact of that species occurring at low population densities and/or possessing an irregular distribution in response to varying habitat factors, biological interactions and availability of energy resources (Boulton 2000, Boulton *et al*. 1998, Humphreys 2009). It is considered unlikely that the actual species distribution is confined to the limited area from which it has so far been collected.

Biological and physical surrogates can assist in determining likely species distributions and addressing the sampling difficulties associated with subterranean fauna (EPA 2013a). Reviewing records of closely-related species, or species collected sympatrically (biological surrogates), and the expanse of neighbouring geological habitat (physical surrogate) can provide further insights into the potential distribution patterns of species that are known from a few records only.

Physical and biological evidence indicating the likely wider distribution of *Chiltoniidae*-SAM6 is as follows:

- Physical: The geological and hydrogeological assessments of the Hinkler Well calcrete indicate that the Millipede deposit is part of the same geological and aquifer unit as Centipede, with both deposits hosted within the deltaic calcrete depositional setting. The Hinkler Well calcrete delta extends from the lake playa for more than 6 km to the west to the Erawalla Fault. Between the Erawalla Fault and the lake playa the calcrete profile varies in thickness from 0.5 m to 24 m (Aquaterra 2010d). The distribution of a number of the stygofauna species either side of the Erawalla Fault indicates that the uplift of the bedrock has not isolated the western portion of the Hinkler Well calcrete aquifer from the eastern delta aquifer system.

- Biological: *Chiltoniidae*-SAM6 was collected sympatrically with four stygofauna species/subspecies, *Atopobathynella wattsi*, *Fierscyclops fiersi*, *Halicyclops eberhardi*, *Nitokra* sp. TK1, and *Nitokra* sp. TK2, all of which possess distributions that extend beyond the Millipede deposit into the broader Hinkler Well calcrete. The broader distributions of the sympatric species recorded indicate that the aquifer sampled within the Millipede deposit is connected to, and forms part of the greater calcrete aquifer associated with the Hinkler Well calcrete (i.e. the groundwater associated with the Millipede deposit is not an isolated aquifer). This finding is consistent with the geological and hydrogeological evidence.

The closely related *Chiltoniidae*-SAM3 (8.9 to 9.5 % genetic divergence) is widely distributed within the Hinkler Well calcrete. The geographical range of this species extends from the mesosaline to hypersaline groundwater conditions within the Centipede deposit more than 18 km to the west to the freshwater conditions within the western portion of the calcrete system. In addition, *Chiltoniidae* species collected from Lake Violet and Uramurdah calcretes were demonstrated to possess relatively widespread distributions within their respective calcrete systems, with *Chiltoniidae* sp. SAM1b distribution extending from Lake Violet calcrete more than 30 km to the north west to Millbillillie Bubble Well calcrete (Outback Ecology 2012a - Appendix 10.26). These species also displayed a tolerance for varying groundwater conditions from saline to freshwater conditions. *Chiltoniidae*-SAM6 was collected from mesosaline groundwater conditions that became hypersaline at 2 m depth. *Chiltoniidae*-SAM6 is considered likely to display a similar tolerance to varying groundwater salinity levels and broader distribution range as displayed by other closely related chiltoniid species also from Lake Way associated calcrete systems.

Intra-specific (within species) genetic variation displayed between the two specimens of *Chiltoniidae*-SAM6 sequenced was 1.2% which was marginally greater than that displayed for the more commonly collected *Chiltoniidae*-SAM3 with 1.1%. The co-occurrence of a higher level of haplotype diversity among specimens collected within a limited geographical area can be an indication of a relatively large and more widespread population than location records may show.

It is considered unlikely that the distribution of *Chiltoniidae*-SAM6 is confined to the Millipede deposit area and associated modelled groundwater drawdown contours when taking into account the physical and biological evidence that demonstrates:

- Presence of suitable and connected habitat beyond the proposed Millipede pit areas; and
- High likelihood that *Chiltoniidae*-SAM6 has a relatively widespread distribution and is able to tolerate varying groundwater salinities.

The implementation of the proposed mining of the Millipede and Centipede deposits is not considered likely to pose a long term conservation risk to *Chiltoniidae*-SAM6 when taking into consideration:

- Limited area of habitat removal associated with mining excavation and associated dewatering groundwater drawdown, relative to the much greater expanse of adjacent habitat that would remain;
- Broader distribution patterns and habitat preferences of closely related chiltoniid species; and
- Broader distribution patterns of other members of the stygofauna assemblage, many of which were collected sympatrically.

Barwidgee Calcrete: Potential Impacts on Subterranean Fauna Habitat

The impact assessment outlined below focuses on the mining operations area only, as no species of stygofauna or troglofauna were found to be of conservation concern as a result of the proposed borefield.

Mining at Lake Maitland is expected to directly impact approximately 388 ha, or approximately 1.3% of the Barwidgee Calcrete PEC. Refer to Table 12.12.

Table 12.12: Potential extent of subterranean fauna habitat impacted for Lake Maitland associated Barwidgee calcrete stygofauna PECs

Extent (ha)	Lake Maitland mining area impact, ha	Lake Maitland mining groundwater drawdown impact, ha	Lake Maitland borefield groundwater drawdown impact, ha	Combined Groundwater drawdown and mining area direct impact (% of PEC)	Mining Area impact only (% of PEC)
30092.4	388.4	4021.04	0	13.4%	1.3%

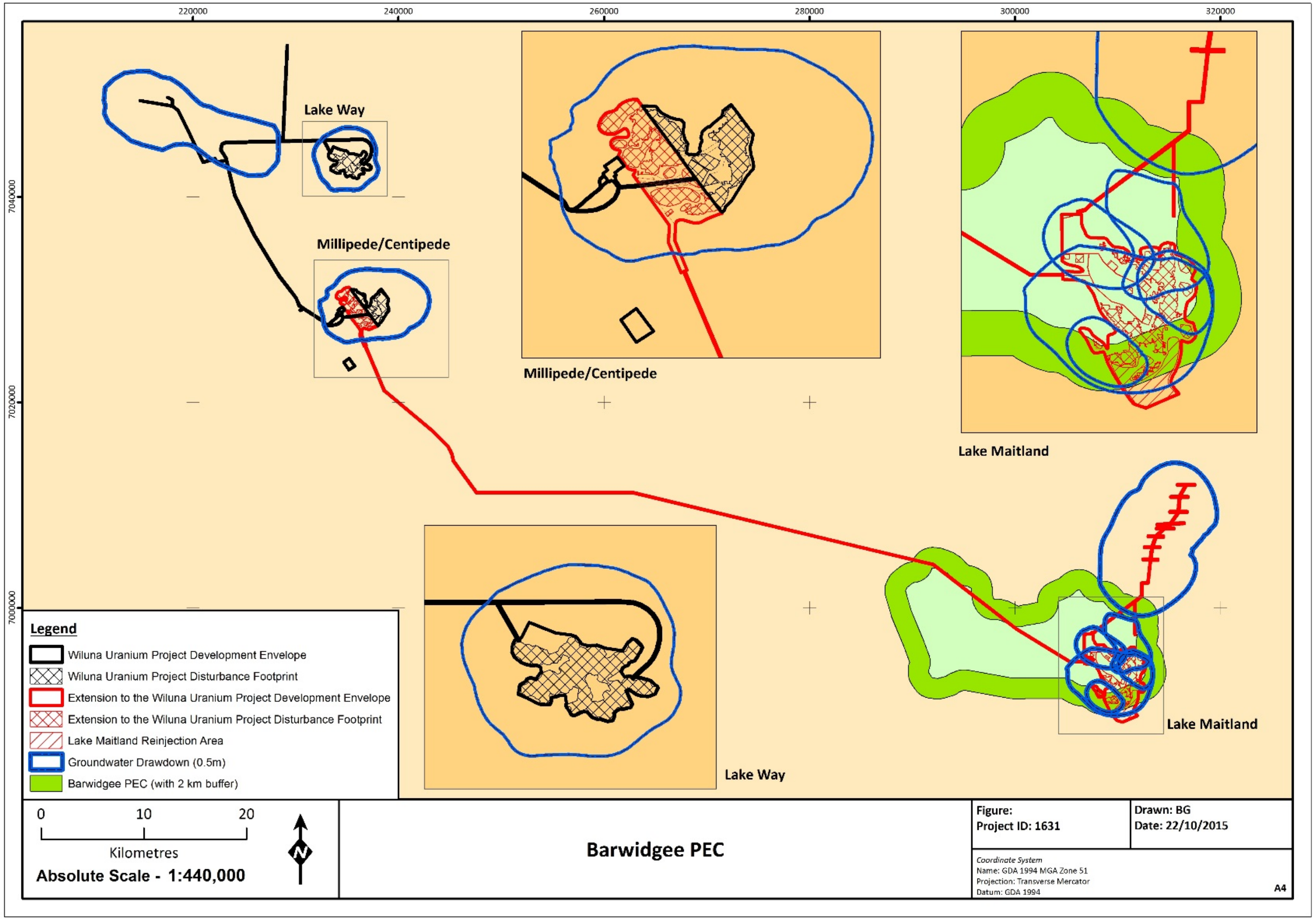
In the event that the proposed low permeability perimeter barriers around the mine pits are wholly ineffective, groundwater drawdown associated with mine dewatering may give rise to indirect impacts over an area of up to 4021 ha, or approximately 13.4% of the extent of the Barwidgee Calcrete PEC (Figure 12.14). This is a worst case estimate. Because mining is conducted in a series of mining panels, the drawdown areas change over time. It is extremely unlikely that as much as 13.6% of the PEC would be affected at any given time. The value of 13.6% represents the maximum proportion of the PEC that could be affected in total over the life of the Wiluna Uranium Project and its Extension. In practice, less than half of this area is likely to be affected by mine dewatering drawdowns at any given time (since only areas around the active mining panel(s) will exhibit significant drawdown).

The proposed groundwater drawdowns associated with mine dewatering are not considered likely to disrupt the salinity gradients (haloclines) present within the calcrete aquifers and pose additional impacts to stygofauna. Excessive groundwater pumping is hypothesised to potentially alter or disrupt haloclines, thereby impacting the trophic dynamics supporting stygal communities. In the case of mine dewatering at both Millipede/Centipede and Lake Maitland, the groundwater inflow into an excavated mine panel would predominantly consist of horizontal flow from the upper several metres of the surrounding aquifer system (RPS 2015b – Appendix 10.56). The upper groundwater surrounding the proposed mining areas ranges from hyposaline to hypersaline, but is mostly hypersaline (MWH 2015 – Appendix 10.11; Outback Ecology 2012c – Appendix 10.28).

The horizontal inflow that would occur during dewatering of the shallow mine pits is not considered likely to cause disruptions to the freshwater conditions that exist further away from the lake playas through mixing with the denser, underlying higher saline groundwater. Instead, it is expected that the halocline stratification that may exist would remain intact (RPS 2015b – Appendix 10.56) and not pose any additional impact to stygofauna present.

A further possible source of indirect impact to subterranean fauna habitats is the proposed reinjection of surplus mine water at Lake Maitland. In order to meet its commitment not to discharge surplus water to the Lake Maitland playa, Toro has investigated the feasibility of returning groundwater intercepted by mining to the aquifer from which it was abstracted (Pennington Scott 2015b - Appendix 10.30).

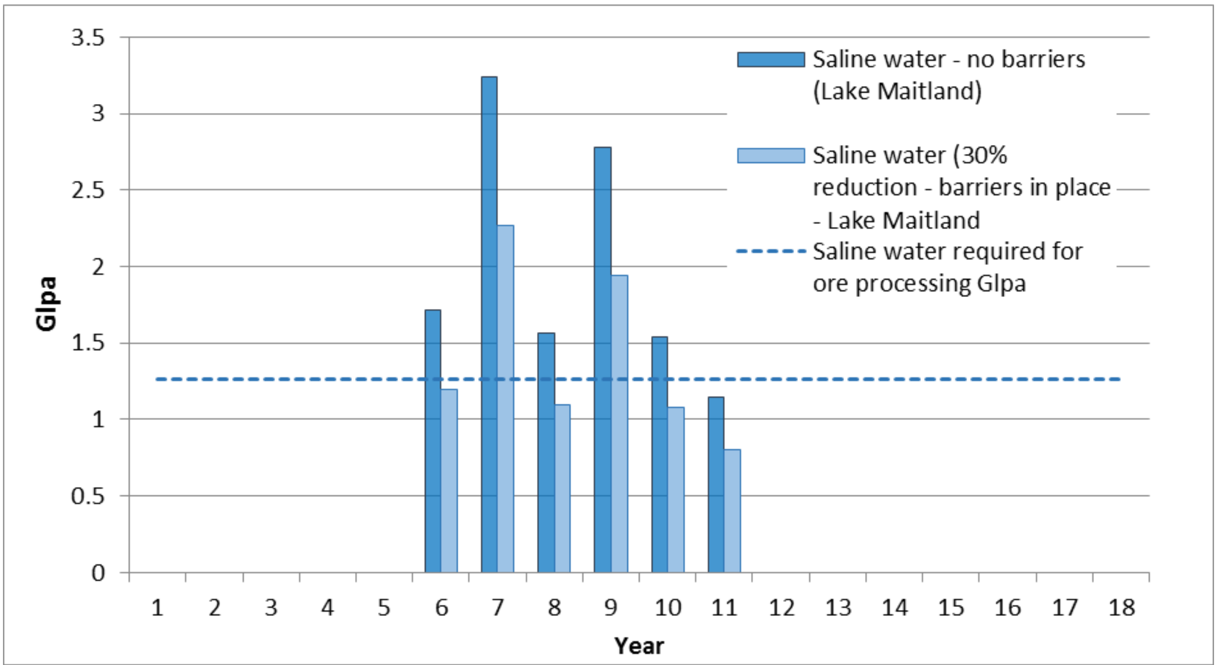
Figure 12.14: Subterranean PECs – Lake Maitland



This process would involve the reinjection of hypersaline water taken from the ore body into aquifers of comparable salinity levels within the Project area. A preliminary water balance study (Golder, 2015 – Appendix 10.9) has estimated that surplus water would be generated, on average, in two years out of the proposed six year mining program, if the proposed perimeter barriers are ineffective (Figure 12.15).

In the event that groundwater reinjection is required, it is likely to be of limited magnitude (less than 1 GLpa) and duration. During injection, there would likely be mixing of the injected water with the existing groundwater immediately around the injection bores and within the injection borefield. At cessation of reinjection, mounding of the groundwater table in the reinjection area would gradually dissipate and the water table would recover to pre-injection levels. Any salinity gradients that existed prior to reinjection (thin layers of low salinity water at the top of the water table) would be re-established following rainfall recharge events.

Figure 12.15: Estimated mine dewatering surplus (Lake Maitland)



Barwidgee Calcrete: Potential Impacts on Conservation Significant Subterranean Fauna

The removal of habitat through mining excavation poses a risk to two of the three species that are of conservation concern. These are *Chiltoniidae* sp. SAM4 and *Schizopera* sp. TK1. The removal of habitat through the lowering of the groundwater table as a result of mine pit dewatering poses a risk to *Haloniscus* sp. OES1, the remaining species of conservation concern.

Chiltoniidae sp. SAM4

Chiltoniidae sp. SAM4 is only known from a single bore, EH01, located south of the surface expression of the Barwidgee calcrete within a low lying areas fringing the lake playa where groundwater salinity levels present in the upper stratum of the water column of the bore were hypersaline (105.9 mS/cm). The low lying environment fringing the lake playa is relatively extensive and consists at the surface of clays/silts with a salt crust.

The distribution ranges and habitat preferences of stygofauna species that are known from only a few records are difficult to reliably assess. The seemingly restricted distribution of a species to only one or two bores is likely to be an artefact of that species occurring at low population densities and/or possessing an irregular distribution in response to varying habitat factors, biological interactions and availability of energy resources (Boulton 2000, Boulton *et al.* 1998, Humphreys 2009), rather than the actual distribution being confined to such a limited area that perchance was intercepted by a single bore. Reviewing records of closely related species, or species collected sympatrically, can provide further insight into the potential distribution patterns and habitat preferences of species that are known from a few records only.

Genetic data was successfully sequenced from *Chiltoniidae* sp. SAM4 specimens collected to confirm morphological assessments and to investigate evolutionary relatedness with other *Chiltoniidae* species from the Carey palaeodrainage system. The phylogenetic analysis of the CO1 gene fragment sequenced showed the intraspecific genetic divergence was 2.4% for the two *Chiltoniidae* sp. SAM4 specimens that were collected in the same sample (Leijs 2011a). This undescribed species is morphologically and genetically distinct from the more abundant and widely distributed *Chiltoniidae* sp. OES1 that was also collected in this study (Outback Ecology 2012c – Appendix 10.28). However, DNA sequence data showed *Chiltoniidae* sp. SAM4 was more closely related to *Chiltoniidae* sp. OES1, with a genetic divergence of 13.8 to 14.9%, than were other Chiltoniid species sequenced from Lake Way calcretes. The Chitoniid species from Lake Way showed a genetic divergence from the widely distributed *Chiltoniidae* sp. OES of 15.6 to 17.1 %.

Investigations have shown that *Chiltoniidae* sp. OES1 occurs throughout the Barwidgee calcrete, ranging from near the Lake Maitland uranium resource area to more than 10 km westward. The species exists in groundwater environments that range in salinities from hyposaline to mesosaline. In the Lake Way associated calcretes, two chiltoniid species have been confirmed by molecular analysis to be relatively widespread and to also exist within a broad range of groundwater salinity levels (Outback Ecology 2011h - Appendix 10.64). *Chiltoniidae* sp. SAM3 from the Hinkler Well calcrete was demonstrated to have a distribution that ranged from along the margin of the Lake Way playa, in hypersaline groundwater environments that exceeded 108 mS/cm, to more than 16 km westward up the Hinkler Well calcrete, in fresh groundwater with salinity levels as low as 2.6 mS/cm (Outback Ecology 2011h - Appendix 10.64). More commonly, the salinity levels that *Chiltoniidae* sp. SAM3 specimens were collected from were in the hyposaline (5–30 mS/cm) to mesosaline (30–70 mS/cm) range. The distribution range of *Chiltoniidae* sp. SAM1 was found to extend for more than 30 km from Millbillillie Bubble Well calcrete, approximately 18 km north west of Wiluna, to Uramurdah calcrete, approximately 14 km south east of Wiluna (Outback Ecology 2011h - Appendix 10.64).

The salinity levels that *Chiltoniidae* sp. SAM1 specimens were recorded from also ranged from hyposaline to mesosaline groundwater environments (Outback Ecology 2011h - Appendix 10.64). The chiltoniid species discussed above were mostly collected from calcrete habitats. The possible exception to this may be for the bores located near to the Lake Way playa in which *Chiltoniidae* sp. SAM3 was recorded where the amount of calcrete that may have been present was not known (that is, the specimens could have be living in an alluvial layer). The data collated indicate that, although chiltoniid species can tolerate hypersaline environments near to salt lake playas where the extent of calcrete may be limited, the preferred environments where species were more commonly collected are less saline conditions within calcrete geologies.

Four other species of stygofauna collected sympatrically with *Chiltoniidae* sp. SAM4 from Bore EH01, *Halicyclops* sp. TK1, *Halicyclops* sp. TK2, *Nitokra lacustris pacifica*, and *Nitokra* sp. TK3, were also recorded from bores outside of the mining operations impact areas. Each of these species was found to be able to exist within a broad range of groundwater salinity levels ranging from the hypersaline environment near the lake playa to hyposaline conditions further westward up the Barwidgee calcrete system at and beyond Little Well. The broader distributions and habitat preferences of these four species indicate that contiguous habitable saturated geologies do extend beyond the mining operations impact areas from along the margins of the northern lake playa system.

A wider distribution range for *Chiltoniidae* sp. SAM4 beyond the mining operations resource area was not demonstrated during baseline studies, or from other accessible records for the area. However, when considering the wider expanse of potential habitat outside of the resource area, the wider distribution patterns and habitat preferences of other chiltoniid species, as well as other sympatric stygofauna, it is likely that the distribution range of *Chiltoniidae* sp. SAM4 is of wider extent within the Barwidgee calcrete – Lake Maitland playa system and not confined to the immediate vicinity of the bore from which it was collected.

The proposed mining of the resource area is not considered likely to pose a long-term conservation risk to *Chiltoniidae* sp. SAM4 when taking into consideration the:

- Limited area of calcrete habitat removal associated with mining excavation, relative to the much greater expanse of adjacent calcrete habitat remaining;
- Broader distribution patterns and habitat preferences of other chiltoniid species; and
- Broader distributions habitat preferences of other sympatric members of the stygofauna assemblage.

***Schizopera* sp. TK1**

The distribution of *Schizopera* sp. TK1 is known to extend for over 10 km from the northern resource area down to the southern resource area of the Lake Maitland deposit. Six specimens of *Schizopera* sp. TK1 were collected in May 2007 from bores LMAC0352 and LMAC0448, and in March 2010 from bore EH01. Only bore LMAC0352 was sampled on one further occasion in 2008, but no additional specimens were collected. All three bores occur within the low lying areas fringing the lake playa where groundwater present in the upper stratum of the water column of each bore were hypersaline with values ranging from 105.9 to 132.3mS/cm. The range in salinity levels in the aquifer occupied by other more widely distributed *Schizopera* species have been reported to range from hyposaline to hypersaline (Outback Ecology 2011h - Appendix 10.64).

The bore lithology for EH01 is not known. However, lithologies for bores LMAC0352 and LMAC0448 indicate that *Schizopera* sp. TK1 is not confined to calcrete habitat only. No calcrete was present in LMAC0352: the shallow aquifer at that location consisted of clay and ferricrete. At LMAC0448, over 1.4 m of saturated calcrete habitat was recorded.

Schizopera sp. TK1 has been collected sympatrically with seven species, *Ameiropsyllus* sp. TK1, *Halicyclops* sp. TK1, *Halicyclops* sp. TK2, *Haloniscus* sp. OES1, *Naididae* sp. OES2, *Nitokra lacustris pacifica*, and *Nitokra* sp. TK3. The distributions of these seven species extends beyond the proposed Lake Maitland mining operations area further to the west of the Barwidgee calcrete body. All are known to occur in less saline groundwater and within more substantial calcrete habitats. The broader distributions and habitat preferences of these sympatric species indicate that contiguous habitable saturated geologies extend beyond the mining operations resource area from along the margins of the northern lake playa system from where *Schizopera* sp. TK1 was recorded.

A distribution range beyond the Lake Maitland uranium resource area was not demonstrated by Toro's baseline investigation or from other accessible records for *Schizopera* sp. TK1. However, when considering the wider expanse of potential habitat outside of the resource area, the wider distribution patterns and habitat preferences of other *Schizopera* species, as well as other sympatric stygofauna, it is likely that the distribution range of *Schizopera* sp. TK1 is of wider extent within the Barwidgee calcrete – Lake Maitland playa system and not confined to the mining operations resource area.

The proposed mining of the Lake Maitland uranium deposit is not considered likely to pose a long term conservation risk to *Schizopera* sp. TK1 when taking into consideration the:

- Limited area of calcrete habitat removal associated with mining excavation, relative to the much greater expanse of adjacent calcrete habitat remaining;

- Broader habitat preferences of other *Schizopera* species;
- Broader distribution patterns and habitat preferences of other members of the stygofauna assemblage that were collected sympatrically; and
- Broader distributions habitat preferences of other sympatric members of the stygofauna assemblage.

Impacts on Troglofauna Species

The two potential impacts of the proposed mining activities at Lake Maitland on troglofauna are the direct removal of habitat through mining and the lowering of the groundwater table through mine pit dewatering. Mining and mine dewatering pose varying degrees of risk to the conservation of five of the nine troglomorphic species that have so far only been collected in:

- The proposed mine footprint – *Scolopendridae* sp. OES1;
- The 2 m groundwater drawdown contour zone – *Haloniscus* sp. OES12 and *Tyrannochthonius* sp. OES5; and
- The 0.5 m groundwater drawdown contour zone – *Haloniscus* sp. OES14 and *Pauropoda* sp.

The remaining four troglofauna species, *Meenoplidae* sp. OES1, *Trichorhina* sp. OES6, *Tyrannochthonius* sp. OES4 and *Tyrannochthonius* sp. OES6, are not of conservation concern in that their distributions were demonstrated to extend beyond, or to not occur within, the direct and potential indirect impact zones at Lake Maitland.

Scolopendridae sp. OES1

Only one species, the troglomorphic centipede, *Scolopendridae* sp. OES1, was found from within the proposed Lake Maitland pit shell. The species was represented by a single specimen collected from LMAC0504 in calcrete habitat that would be subjected to direct removal through excavation. If *Scolopendridae* sp. OES1 does only occur in the resource area, then the long-term persistence of this species would be considered unlikely because of the lack of available unsaturated calcrete habitat that would remain within the uranium resource area after mining has occurred. However, the distribution ranges and habitat preferences of species collected in such low numbers are difficult to reliably assess. The seemingly restricted distribution of a species to a single bore is likely to be an artefact of that species occurring at low population densities and possessing an irregular distribution in response to varying habitat factors, biological interactions and availability of energy resources, similar to factors influencing stygofauna distributions (Boulton 2000, Boulton *et al.* 1998, Humphreys 2009), rather than the actual distribution being confined to one limited area that perchance was intercepted by a single bore.

The occurrence and wider distribution from outside the resource area of other members of the troglofauna assemblage that were also recorded from in or around the resource area, notably *Trichorhina* sp. OES6, *Tyrannochthonius* sp. OES4 and *Haloniscus* sp. 12, indicate that the relatively extensive calcrete present provides contiguous and suitable habitats that extend from along the margins of the northern lake playa system to the west along the Barwidgee calcrete. In total, three singleton species were collected in this study, each from calcrete habitats associated with the Barwidgee calcrete system whose surface expression occurs around the lake playa and extends beyond the mining operations impact zones to the west of the bores LT104, LT105 and LT107. Although a wider distribution range for *Scolopendridae* sp. OES1 was not demonstrated during baseline studies, nor from other accessible records for the area, it is likely the distribution range of this species is of wider extent within the Barwidgee calcrete – Lake Maitland playa system and not confined to the immediate vicinity of the bore from which it was collected.

The proposed mining of the resource area is not considered likely to pose a long term conservation risk to *Scolopendridae* sp. OES1 when taking into consideration the:

- Wider distribution of other members of the troglofauna assemblage throughout the calcrete habitats and associated lake playa environments;
- Limited area of calcrete habitat removal associated with mining excavation, relative to the much greater expanse of adjacent calcrete habitat remaining; and
- Relatively short operational life of mining at Lake Maitland.

Mining Operations Groundwater Drawdown Zone

Four troglofauna species collected during baseline studies for the Wiluna Extension Project have so far been found only from within the modelled 2 m or 0.5 m groundwater drawdown contours. These were:

- *Haloniscus* sp. OES12 – collected from bores at LMAC0527 and LMAC0312 within the resource area, as well as from bore LMAC0449 located more than 100 m from the boundary of the resource area within the modelled 0.5 to 1 m groundwater drawdown contours;
- *Haloniscus* sp. OES14 – recorded within the modelled 0.5 to 1 m drawdown contours more than 950 m (LMAC0543) and 750 m (LMAC0403) from the resource area;
- *Pauropoda* sp. – recorded within the modelled 0.5 to 1 m drawdown contours more than 2.3 km (LMST012) and 900 m (LMAC0404) from the resource area; and
- *Tyrannochthonius* sp. OES5 – single specimen collected from bore LMAC0523 located more than 100 m from the resource area within the modelled 1.5 to 2 m drawdown contours.

Troglofauna are considered to represent relictual fauna related to surface dwelling (epigean) groups that have evolved to be obligate inhabitants of subterranean environments that provide more constant and humid refugia (Humphreys 2000b). The reliance of troglofauna on stable and relatively high humidity conditions can make them susceptible to changing water table conditions, particularly if the lowering of the water table is sufficient to rapidly dry out the inhabited zone (EPA 2007). In the case of activities proposed by Toro at Lake Maitland, the magnitude of the proposed groundwater drawdown associated with the mining of the Lake Maitland uranium resource area is not considered to be sufficient to deprive the inhabited subterranean environments of humidity to a degree that would render them uninhabitable by troglofauna.

The modelled drawdowns associated with the proposed mining of the resource area are not considered likely to pose a long-term conservation risk to the species of troglofauna found within the 0.5 m groundwater drawdown contour, taking into account the following additional considerations:

- The proposed lowering of the groundwater will expose additional calcrete habitats that could be colonised;
- The wider distribution of other members of the troglofauna assemblage throughout the calcrete habitats and associated lake playa environments; and
- The existence of adjacent calcrete habitat remaining outside the lateral extent of the 0.5 m groundwater drawdown contour.

12.7 Impact Management

Table 12.13: Mitigation hierarchy for subterranean fauna

Potential Impact	Mitigation Approach	Details
Habitat Loss	Minimise/reduce	Habitat loss would be unavoidable. However, selective mining techniques using the surface miner would allow Toro to limit disturbance from mining.
Mine Dewatering	Minimise/reduce	Water barriers would be installed to reduce the volume of water to be dewatered during the life of the operations.
Groundwater Reinjection	Minimise/reduce	At Lake Maitland saline groundwater reinjection has the potential to lead to previously relatively fresh water areas becoming saline. Toro has developed a conceptual borefield that reduce potential impacts through judicious siting of injection wells and the use of distributed array of well points to minimise the magnitude of impact.
Seepage from TSF	Avoid	The lining of the TSF wall coupled with the water barrier would act to prevent the spread of contaminants from the TSF.

12.7.1 Habitat Loss

Some subterranean habitat loss as part of implementation of the Proposal is unavoidable as the calcrete which hosts the uranium also hosts stygofauna and troglofauna populations. The proportion of habitat to be removed by mining is extremely small when compared to the total habitat available in local and regional calcretes that surround the Project area (Outback Ecology, 2011h – Appendix 10.64; Outback Ecology 2012c – Appendix 10.28).

Studies of local stygofauna and troglofauna populations have shown that most of the species observed are distributed over a wide geographic area. There is no plausible basis for assuming that species so far observed only within proposed disturbance areas are restricted to those areas (unless they are reliant on high uranium habitats). Failure to collect a species from outside the impact areas is almost certainly an artefact of sampling. Recent EPA reports have recognised the fluctuating character of subterranean fauna populations and have endorsed management and monitoring of habitat, rather than direct sampling of subterranean fauna, as an appropriate and effective impact assessment strategy (EPA, 2014).

Outside of mining areas, groundwater drawdown has the potential to eliminate troglofauna habitat by reducing humidity and therefore making the habitat unsuitable. It is likely that there is suitable troglofauna habitat throughout the Barwidgee and Hinkler Well calcretes and, as demonstrated previously, the vast majority of these calcretes would remain intact. Outside of direct mining areas, it is unlikely that the drawdown of groundwater would significantly reduce the humidity within habitats to render them inhospitable (Outback Ecology, 2012c – Appendix 10.28).

12.7.2 Mine Dewatering

Toro has committed to restricting groundwater drawdown for the mining of Millipede to the levels approved following EPA Assessment 1819. This would be achieved by the installation of water barriers around the perimeter of mine pits which would reduce the ingress of water into the pits and thus decrease the water to be abstracted. For this reason, dewatering of the Millipede deposit is unlikely to result in any material increase in the loss of stygofauna habitat over and above that already approved under Ministerial Statement 913.

The same barriers would also be installed at Lake Maitland. Modelling undertaken by the previous owner of Lake Maitland developed a series of drawdown contours, and Toro will commit to having no impacts to stygofauna beyond the 0.5 m drawdown contour (without barriers). Field studies undertaken by both Toro and Mega have shown that barriers are effective in reducing water ingress, with up to an 80% reduction in ingress demonstrated at Centipede and up to 27% reduction demonstrated at Lake Maitland (Toro, 2011b; Golder Associates, 2011b).

Recent experience at other mine sites in the Wiluna region has found that the effects of changing groundwater levels on stygofauna populations are much less than had been assumed (Bennelongia Pty Ltd, 2013).

Toro has developed a groundwater drawdown management plan which outlines how drawdown would be managed and specifies trigger levels at which action would be taken. Observation bores would be installed prior to the commencement of mining, and these would be fitted with downhole level logger devices. The loggers would provide real time data on actual compared to modelled drawdown. Where drawdown was exceeding modelled amounts, contingency action would be initiated. Contingencies could include:

- Reviewing water barrier design;
- Redoing the modelling using real data to assess the full impacts of additional drawdown; and
- Reviewing the mine plan and mine schedule so that smaller areas required dewatering, thereby reducing drawdown.

Mine dewatering and groundwater abstraction are unlikely to result in long-term risks to stygofauna and troglofauna. The extent of the subterranean fauna habitat that would be affected by groundwater drawdown is small relative to the size of the aquifers available to the subterranean fauna. The limited duration of mining and the predicted rapid recovery of groundwater levels post-mining also suggest that there would be no long-term impacts to subterranean fauna in the Project area.

12.7.3 Groundwater Reinjection

At Lake Maitland, up to 1 GL/a of groundwater would be reinjected into the local calcrete aquifer. A field trial in December 2014 and January 2015 confirmed that the aquifer was capable of receiving up to 1 GL/a for 15 years without giving rise to significant groundwater mounding. Implementation of mining at Lake Maitland would require operation of the reinjection system for up to six years, although recent water balance studies (Golder Associates, 2015 – Appendix 10.9) indicate that use of the reinjection system may not occur in every year during the life of mining at Lake Maitland (in some years, all water arising from mine dewatering would be required for ore processing). If the proposed low permeability perimeter barriers around the mine pits perform to the same level of efficiency as has already been demonstrated in field scale trials, then the need for a reinjection system may be entirely avoided.

The mounding associated with reinjection from pit dewatering has the potential to spread hypersaline water and could impact the stygofauna in the Barwidgee calcrete, parts of which are characterised by lower salinity groundwater. During detailed engineering design of the reinjection system, Toro would optimise its configuration and location to ensure that mixing of hypersaline and fresh waters is minimised. This would be done though a distributed borefield configuration with multiple bores and injection sites. Monitoring of mounding and salinity within the Barwidgee calcrete would occur and where salinity or mounding was seen to be rising, reinjection would switch to different bores to allow natural groundwater levels to recover.

12.7.4 Borefield Operations

Hydrogeological modelling conducted to estimate the extent and magnitude of groundwater drawdown from a proposed 1.3 GL/a borefield to the north of the Lake Maitland mining area estimated that after 13 years of borefield operation, a drawdown of 0.5 m would extend for a maximum distance of 7.5 km to the north and approximately 4 km to the east and west of the borefield (RPS Aquaterra, 2011c) (Figure 12.16). No significant cumulative effects of drawdown are expected to result from interaction with mine dewatering.

The predicted maximum extent of drawdown near the centre of the borefield was approximately 5.5 m, which corresponds to less than 25% of the saturated aquifer thickness. This means that around 75% of the local subterranean fauna habitat thickness would remain available, even under the maximum predicted drawdown. The modelling estimated that after water abstraction from the borefield ceases, the water levels in the area would achieve at least 75% recovery over a period of about 30 years. The recovery period could be less, if one or more major rainfall events occur after closure of the borefield.

12.8 Best and Worst Case Assessment of the Impacts to Subterranean Fauna

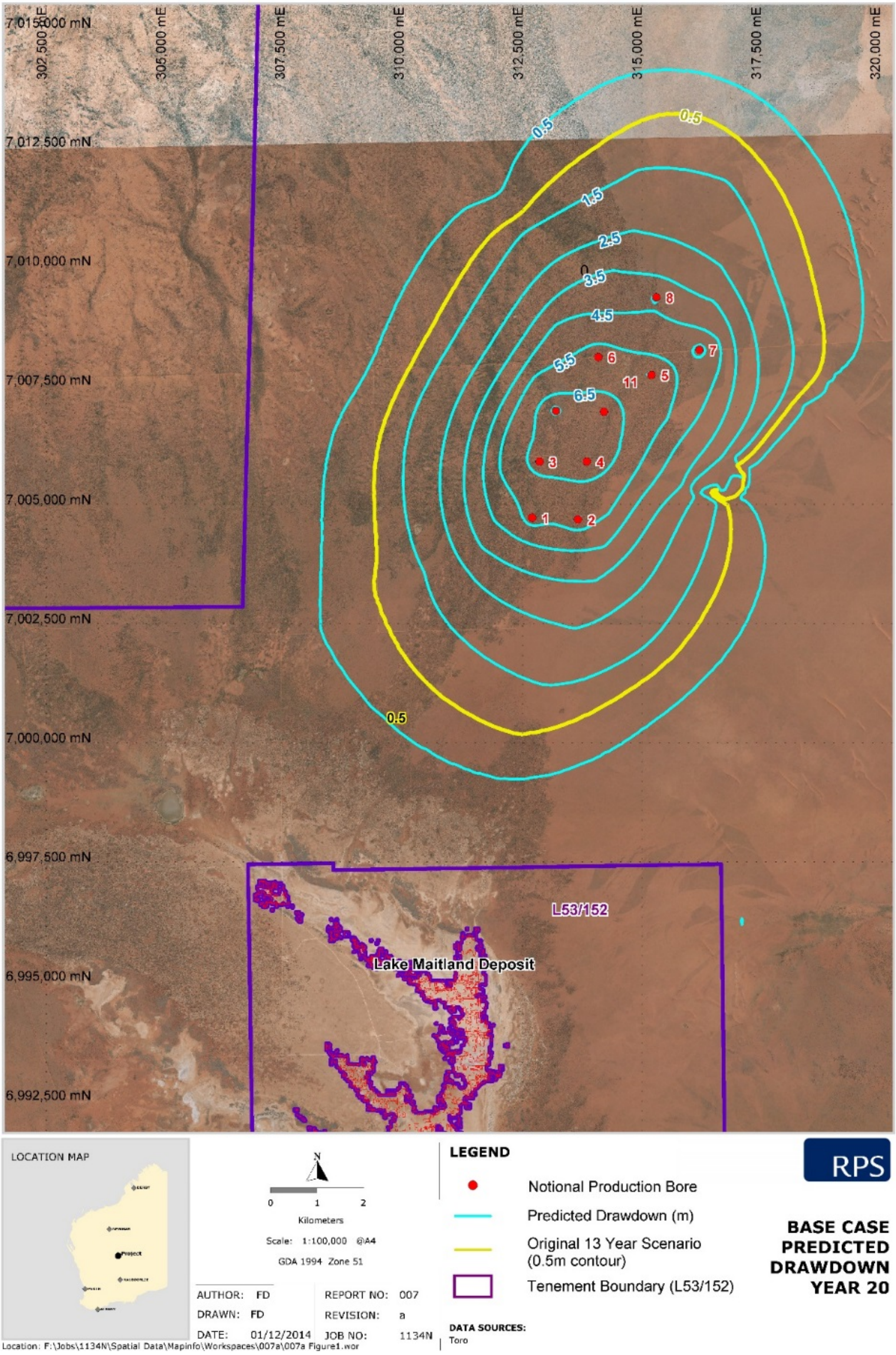
Implementation of the Proposal could impact subterranean fauna communities through the removal of habitat or abstraction and reinjection of groundwater. The potential impacts included in this PER are considered to be worst case scenarios.

Habitat removal through the mining of the calcrete would be the biggest potential direct impact to stygofauna. However, the volume of calcrete habitat that would be removed during mining at Millipede and Lake Maitland would be a very small proportion of the overall extent of the calcrete units. The configuration of the mine pits does not sever the connection between potential habitat areas and therefore would not have the effect of reducing the geographic range of species occurrence or hindering genetic exchange between fauna populations.

Dewatering impacts would be managed with the use of low permeability barriers around the pits to limit the volume of water required to be abstracted. Trials conducted by Toro have determined that significant reductions in groundwater ingress are possible with the use of compacted clay barriers around the perimeter of the mine pits. This would significantly reduce the volume of water to be abstracted which would in turn reduce the groundwater drawdown and impact areas.

During operations, the Subterranean Fauna Management Plan would be implemented and regular monitoring of groundwater abstraction would occur. This would allow Toro to determine if any further reductions in impacts to subterranean fauna were necessary.

Figure 12.16: Lake Maitland hydrogeological model – borefield drawdown



12.9 Commitments

To ensure that the actual impacts on stygofauna populations are no more than predicted, Toro would implement the Environmental Management Plan (Appendix 4). The plan would include the following:

- Regular monitoring of groundwater levels in line with the modelled drawdown contours to ensure that drawdown levels are below threshold values;
- Use of water barriers around mine pits to reduce dewatering;
- Ongoing periodic monitoring of groundwater chemistry to ensure any changes are detected as soon as possible and changes to the operation can be implemented if required to manage impacts;
- Further modelling of tailings behaviours to assess the impacts of seepage under realistic conditions;
- Reinjection to be managed to prevent salt water intrusion into fresh or brackish water systems;
- Regular monitoring of groundwater salinity and TDS in the Hinkler Well and Barwidgee calcrete to ensure water quality is maintained;
- Implementation of the Groundwater Management Plan at the commencement of the operational phase; and
- The development of a subterranean monitoring program to include measurable habitat parameters, such as temperature and relative humidity of the subterranean environment, as well as sampling using litter trapping and/or net haul sampling.

12.10 Outcome

The long-term conservation risks to subterranean fauna assemblages at Millipede and Lake Maitland are predicted to be low because:

- There are wide distributions of many of the species detected through the calcrete aquifers, as well as neighbouring calcretes;
- Removal of substrate by mining would result in loss of a very small proportion of the available subterranean fauna habitat;
- Water abstraction would be managed to limit changes to groundwater levels and maintain at least 70% aquifer saturation;
- Water barriers would be implemented to reduce the magnitude and extent of dewatering impacts from pit dewatering; and
- The operational life of the Proposal would be relatively short.

This outcome is consistent with the aim of this key environmental factor. The relatively short life of the Project along with the selective mining of the calcrete would ensure that the removal of subterranean fauna habitat was minimised. Recoveries of local groundwaters are reported on in Section 13 and show that at closure groundwater levels within the dewatering zones would recover quickly.

12.11 Cumulative Impacts

The distribution of the various components of the Wiluna Uranium Project and its Extension is such that activities that could impact subterranean fauna assemblages do not overlap.

For example, groundwater drawdown from the West Creek borefield would not intersect drawdown cones from proposed mining activities at Millipede/Centipede or Lake Way. Although the zone of influence of the West Creek borefield would extend to the former Wiluna South borefield, these impacts were already considered under the ERMP conducted for the approved Wiluna Uranium Project.

A recent review of groundwater behaviour associated with this Proposal concluded that the groundwater drawdown at West Creek would not overlap with the Wiluna East borefield, which could be recommissioned in the event that Blackham Resources were to re-open the former Apex gold mine (RPS, 2015b – Appendix 10.56).

Managing the cumulative impacts of water abstraction in the West Creek/Wiluna South area is a matter that can be regulated by the Department of Water through its licensing powers under Section 5C of the *Rights in Water and Irrigation Act 1914*.

At Lake Maitland, as discussed in Section 13.7 of the PER, no significant cumulative drawdown is expected to result from overlap of the proposed borefield operation with groundwater drawdown from mine pit dewatering. None of the groundwater drawdown areas overlap existing subterranean fauna modification from other existing sources (other mining activities, for example). This is important because it allows each impact area to be monitored and managed independently.

The impacts of the proposed mining and dewatering activities are additive in the sense that each results in some modification of the overall subterranean fauna habitat. However, the subterranean fauna population shows many species in common throughout the geographic extent of the Project and beyond the areas of potential impact. The similarities in species composition between the various calcrete units occurring in the Project area and the demonstrated cosmopolitan character of many of the species suggest that the proportion of the subterranean fauna population that could be affected by Project implementation is small, relative to the size of the available habitat. Local scale impacts arising from changes in groundwater levels would be transient. The implementation of the Proposal is not expected to significantly alter the cumulative effect of threatening processes on stygofauna or troglofauna at a regional level.

13 INLAND WATER QUALITY AND HYDROLOGICAL PROCESSES

13.1 Objectives

To maintain the quality of groundwater, surface water, sediment and biota so that the environmental values, both ecological and social, are protected.

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

13.2 Relevant Legislation and Policy

The DoW's *Western Australian water in mining guideline* sets out how to meet the department's regulatory requirements for mining projects. The guideline draws on the *Rights in Water and Irrigation Act 1914*, policies, water allocation plans and regional experience in water management issues.

Under the Act, the DoW issues licences and permits that protect the state's water resources and promote sustainable and efficient use of water. The DoW also has a state-wide Environmental Water Provisions Policy to provide for the protection of water-dependent ecosystems whilst allowing for the management of water resources for their sustainable use and development. This policy outlines the guiding principles to be followed by the DoW when making decisions related to the provision of water to the environment. With respect to surface water, the Act provides that disturbance to creek beds and banks cannot be undertaken without a section 11/17/21A approval.

The Australian and New Zealand Environment Conservation Council (ANZECC) and the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) have developed the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC, 2000) as part of Australia's National Water Quality Management Strategy. The main objective of the guidelines is:

> 'to provide an authoritative guide for setting water quality objectives required to sustain current or likely future environmental values for natural and semi-natural water resources in Australia and New Zealand.'

Environmental values that apply to surface waters and groundwaters associated with this Proposal are:

- Aquatic ecosystems;
- Aesthetics and recreation;
- Primary industry uses (livestock); and
- Cultural and spiritual values.

Surface waters within and around the Proposal area are ephemeral and (when present) generally range in salinity from brackish to saline. Surface water in the Wiluna area (including Lake Maitland) is therefore unlikely to be used for drinking water. Groundwater quality in areas proposed for mining at Millipede and Lake Maitland is also too saline for domestic water use, irrigation or watering of livestock. The most relevant health-based water quality guideline for assessment of surface and groundwater water quality in the proposed mine operations area is the WA Department of Health *Contaminated sites ground and surface water chemical screening guidelines* – non-potable groundwater use (2014). The *Australian Drinking Water Guidelines 2011* (NH&MRC, 2015) would also be relevant to groundwater in the proposed borefield to the north of Lake Maitland.

13.3 Proponent Studies and Investigations

The long history of exploration and mining in the Wiluna area has resulted in numerous investigations into surface hydrology and groundwater. Toro's assessment of the potential impacts on inland waters of implementing this Proposal has made use of the studies listed in Table 13.1, many of which have been conducted specifically for the Wiluna Uranium Project, including its extension, or for the former owner of Lake Maitland.

Table 13.1: Summary of studies relevant to inland waters

Author and Title	Summary of Matters Addressed
Aquaterra, 2007a. 'Lake Way/Centipede Deposit Stage 1: Data Review & Proposed Scope of Work'. Unpublished report number 793/B1/018b, prepared for Nova Energy Ltd, July 2007.	Literature review of previous hydrogeological studies in the Wiluna region.
Aquaterra, 2007b. 'Costean Programme Dewatering Assessment Centipede Deposit', Report No. 793/B2/045a. Unpublished report prepared for Nova Energy Ltd, October 2007.	Small-scale dewatering tests of three costeans at Centipede over the period 12–16 June 2007 to assess the hydraulic properties of the calcrete and potential pit inflow rates.
Aquaterra, 2010a. 'West Creek Water Supply Groundwater Modelling', Report No. 1134/C/104a. Unpublished report to Toro Energy Limited, June 2010. (Appendix 10.57)	Assessment of the groundwater abstraction potential of a rehabilitated/upgraded West Creek borefield
Aquaterra, 2010b. 'Wiluna Uranium Project – Surface Hydrology Studies', Report No. 1134/B/098a. Unpublished report prepared for Toro Energy Limited, September 2010.	Surface water studies to characterise the existing surface water flow regime in and near to the Centipede and Lake Way mine areas, assess potential for flooding of the mine sites and potential impacts of mining on the surface drainage system.
Australian Groundwater Consulting, 1992. 'Mt Keith Process Water Supply Project – Lake Way Area', Report No. E1451. Report prepared for WMC Engineering Services Pty Ltd, December 1992.	Describes groundwater investigations conducted at Lake Way between August and December 1992, including drilling and testing of five production bores. Aim of the study was to identify a reliable source to supply up to 8 GL/a of saline water (TDS 50,000 mg/L).
Australian Groundwater Technology, 2009. 'Wiluna Project – Centipede Resource Pit Dewatering Project Draft', AGT Report No. 2009/242. Report prepared for Toro Energy Limited, 7 July 2009.	Field testing (step-drawdown test and 48 hour constant discharge test on a 10 m deep bore) to determine a preliminary estimate of potential mine dewatering rates at Centipede.
CSIRO, 2009. 'Hydrogeochemical Mapping of Northeast Yilgarn Groundwater', report P2009/1612, MERIWA Project M402. Prepared by D.J. Gray, R.R.P. Noble & N. Reid – commercial in confidence.	Compilation and review of a large hydrogeochemical data set to develop reliable regional hydrogeochemical maps in the NE Yilgarn Craton. The review of carnotite mineral saturation index has predicted most U deposits in the NE Yilgarn Craton.
Golder Associates Pty Ltd, 2011a. 'Lake Maitland Regional Groundwater Modelling: Technical Memorandum'. Unpublished memorandum, 19 May 2011.	Presents details of a regional groundwater model for the Lake Maitland area, including selected results relating to mine dewatering and post-closure groundwater behaviour.

Author and Title	Summary of Matters Addressed
Golder Associates Pty Ltd, 2011b. 'Lake Maitland Uranium Project – Trial Pit Dewatering Programme', report number 097641165 258 R Rev A. Unpublished report prepared for Mega Uranium Pty Ltd, June 2011.	Description of a field trial conducted at Lake Maitland between October and December 2010 to investigate mine dewatering and the use of a groundwater reinjection system at field scale.
Golder Associates Pty Ltd, 2011c. 'Groundwater studies -Lake Maitland Uranium Project', report number 097641165 276R Rev B. Unpublished draft report prepared for Mega Uranium, 17 June 2011.	Comprehensive report on site hydrogeology, mine dewatering and recharge, water supply and water management requirements.
Golder Associates Pty Ltd, 2011d. 'Lake Maitland Uranium Project Geochemical Assessment', report number 097641165-318-R Rev A. Unpublished draft report prepared for Mega Lake Maitland Pty Ltd, 17 June 2011. Appendix (10.53)	Presents results of field and laboratory studies to evaluate geochemical properties of Lake Maitland soil, sediment, overburden, mine wastes and groundwater, with a view to evaluating acid rock drainage, metalliferous seepage and other geochemical impacts of mining at Lake Maitland.
Golder Associates Pty Ltd, 2011e. 'Lake Maitland Uranium Project Hydrologic Studies and Site Water Balance', report number 097641165-308-R Rev B. Unpublished draft report prepared for Mega Lake Maitland, 17 June 2011. Appendix (10.54)	Analysis of rainfall and climate data, flood modelling, development of a site water balance (including borefield water demands) and recommendations of surface water management requirements for mining at Lake Maitland.
Golder Associates Pty Ltd, 2015. 'Technical memorandum – Toro Energy Lake Maitland Dewatering and Water Balance Review', report number 1531480-001-M-Rev0. Unpublished report prepared for Toro Energy Limited, 4 June 2015. Appendix (10.9)	Review of mine dewatering requirements and other components of Lake Maitland water balance.
Johnson SL, Commander DP and O'Boy CA, 1999. *Groundwater resources of the Northern Goldfields, Western Australia*. Hydrogeological Record Series. Water and Rivers Commission, Report HG 2, Perth.	Comprehensive review of borefield and exploration data contained in some 440 consultant and company reports, followed by a program of groundwater exploration including ground-based geophysics, exploration drilling and the installation of monitoring bores.
Klohn Crippen Berger, 2015. Wiluna Uranium Project Extension Hydrogeological & Hydrological Report Review, 15 July 2015. Appendix (10.45)	Independent review and summary of key surface water and groundwater investigations conducted for the Wiluna uranium project expansion.
Peter Clifton & Associates, 2005. 'Investigation of Surface Water and Groundwater Issues – Williamson Project Open Pit, Lake Way, Via Wiluna'. Report prepared for Agincourt Resources Ltd, January 2005, Perth, 41p.	Hydrogeological investigation of lacustrine sedimentary deposits near the Williamson Pit (5 km north-north-west of Centipede).
Pennington Scott, 2015a. 'Toro Energy Limited - Bore Completion Report, Millipede Uranium Project', Rev 2, January 2015.	Factual report documenting bore construction, testing and monitoring results of a groundwater reinjection field trial conducted in the calcrete aquifer at Lake Maitland from December 2014 to January 2015.
Pennington Scott, 2015b. 'Toro Energy Limited - Groundwater Reinjection Study, Lake Maitland Uranium Project', Rev 2, 7 May 2015. Appendix (10.30)	Hydrogeological modelling to evaluate the capacity for reinjection of water from mine dewatering at Lake Maitland.

Author and Title	Summary of Matters Addressed
Prommer H, Davis JA, and Douglas GD, 2015. 'Wiluna uranium project: Long-term fate of uranium and vanadium: Supplementary reactive transport simulations and recommended future investigations'. CSIRO Mineral Resources Flagship, Australia. Unpublished report prepared for Toro Energy Limited, May 2015. Appendix (10.29)	Independent review of previous reactive transport modelling to predict the long-term fate of uranium and other tailings constituents proposed to be stored in mine voids at Centipede and Millipede. Additional one-dimensional model simulations using USGS geochemical model PHREEQCv2 assess the mobility of uranium in groundwater in the event of a loss of containment.
Resource Investigations, 1991. 'Report on groundwater production and water level monitoring – 30/4/89 to 16/1/91, Matilda Gold Project, Wiluna, WA – Groundwater Well Licence Numbers 32065, 32069, 32080 and 32082 for Eon Metal NL', Project No. 049.2, 23 May 1991.	Groundwater investigations in the eastern portion of the Abercromby palaeochannel (drilling of two traverse lines of bores (17 exploration and 23 test holes) spaced ~3 km apart. Field testing to determine aquifer transmissivity and yields from bores constructed in the calcrete and deeper sand aquifer.
Rockwater, 1980. 'Lake Way Project. Groundwater Investigation. Stage 2'. Report prepared for Public Works Department of WA. Wyoming-Delhi-Vam Joint Venture, Lake Way Project.	Describes trench dewatering tests at Lake Way and proposes use of low permeability perimeter barriers to limit groundwater influx. Reinjection of surplus water is proposed (but not tested).
Rockwater, 2011. 'Wiluna Uranium Project – Independent Review of the West Creek Water Supply Modelling Conducted by Aquaterra'.	An independent review of RPS Aquaterra's hydrogeological assessment of the proposed West Creek water supply. The review generally supported RPS Aquaterra's findings, but questioned whether imposing a 40% saturation constraint was an unnecessarily conservative approach to borefield management.
RPS Aquaterra, 2011a. 'Centipede Groundwater Impact Assessment', Report No. 1134C/169b Rev B. Unpublished report prepared for Toro Energy Limited, 17 February 2011.	Hydrogeological modelling to predict pit dewatering volumes from the Centipede mine. Assessment of the impact that the proposed Centipede uranium mine and in-pit tailings storage facility on the magnitude and lateral extent of predicted cones of water level drawdown. Predicted groundwater recovery times following the cessation of dewatering. Preliminary geochemical modelling of the rate of movement and distribution of solutes from in-pit tailings following closure. Predicted concentrations of relevant tailings constituents along expected flow paths.
RPS Aquaterra, 2011b. 'Lake Way Groundwater Impact Assessment', Report No. 1134/C/181b. Unpublished report prepared for Toro Energy Limited, 17 February 2011.	Hydrogeological modelling to predict pit dewatering volumes from the Lake Way mine. Predicted groundwater recovery times following the cessation of dewatering. Particle track modelling to evaluate possible movement of waste rock constituents backfilled into Lake Way mine void.
RPS Aquaterra, 2011c. 'Lake Maitland Uranium Project - Water Supply Investigation', Report No. 716H/600/060b. Unpublished report prepared for Mega Lake Maitland, 25 May 2011.	Presents results of hydrogeological investigations and modelling to assess a potential borefield to the north of Lake Maitland. Field component included geophysical surveys and drilling and testing of 12 bores approximately 15 km north of the Lake Maitland deposit.

Author and Title	Summary of Matters Addressed
RPS, 2014a. 'Memorandum - Summary of West Creek Borefield Modelling Results', report number 017a. Unpublished report prepared for Toro Energy Limited, 4 November 2014. Appendix (10.31)	Review of numerical groundwater modelling (Aquaterra, 2010a) to assess the 'sustainable' yield of the West Creek borefield to provide water to proposed extended ore processing operations for the extension of the Wiluna Uranium Project.
RPS, 2014b. 'Memorandum - Water Supply Modelling Results - Lake Maitland Uranium Project, report number 007a. Unpublished report prepared for Toro Energy Limited, 9 December 2014. Appendix (10.55)	Report builds on previous hydrogeological modelling of the proposed Lake Maitland borefield. Updated models runs evaluate the effects of abstracting groundwater at a rate of 1.3 GL/a over a period of 20 years.
RPS, 2015a. 'Wiluna Uranium Project – Surface Water Studies', report number 1134b/098c, 13 March 2015. Appendix (10.1)	Report describes surface hydrology and surface water quality at Lakes Way and Maitland, characterises frequency, magnitude and duration of flood events, and identifies mitigation strategies to avoid or reduce adverse impacts on surface water.
RPS, 2015b. 'Centipede - Millipede Groundwater Impact Assessment', draft report number 1134J/600/026a, 18 March 2015. Appendix (10.56)	Update of previous groundwater modelling for the Centipede mining area (developed in 2011), taking into account the proposed Millipede mine plan and results of recent site specific mineral exploration drilling and groundwater investigations at Millipede. The revised model was used to predict: dewatering rates and volumes over the life of mine; magnitude and lateral extent of groundwater level drawdown associated with pit dewatering; time for the full recovery of groundwater levels, following the cessation of dewatering. Report also provides an assessment of the cumulative impacts of the Centipede/Millipede Mine and other nearby projects and/or water users on local and regional groundwater.
RPS, 2015c Technical Memorandum prepared for Toro Energy Limited, 23 October 2015. Appendix (10.62)	Response to OEPA and DER comments on groundwater salinity distribution and impacts
Water Corporation, 2004. *Wiluna Water Reserve Drinking Water Source Protection Assessment. Wiluna Town Water Supply*.	Initial assessment of risks to groundwater in the Wiluna Water Reserve, prepared by Water Corporation at the request of the (then) Department of Environment as a first step towards the development of a Drinking Water Source Protection Plan for the catchment.

13.4 Existing Environment – Millipede

13.4.1 Surface Hydrology – Millipede and Lake Maitland

The surface water environments for both Lake Maitland and the proposed Millipede operations area near Lake Way are discussed in this section. This is appropriate because the two mining areas lie on the same palaeodrainage system and the climate factors that drive surface hydrology are effectively the same at both locations. Neither of the proposed mining operations lies within a proclaimed 'surface water management area' under the *Rights in Water and Irrigation Act* (DoW, 2009).

The proposed Millipede mining area is located on the western edge of Lake Way. The lake includes numerous islands, especially in its southern section, which together occupy approximately 15% of the area bounded by its shoreline. The surface elevation of the lake at its deepest point is approximately 490 mAHD. Lake Way is the most upstream lake in a salt lake chain/palaeoriver system which extends to the south-east linking to Lake Maitland (460 mAHD) and Lake Carey (400 mAHD) (Johnson *et al.,* 1999).

Present day drainage is associated with palaeodrainage systems which drain into Lake Way predominantly from the north and west (Aquaterra, 2007a).

Surface water flow is ephemeral and highly dependent on high rainfall events. The dominant Lake Way subcatchments are located to the north and north-west of the lake. These larger catchments have generally poorly defined drainage and are believed to only flow following infrequent major rainfall events (estimated at a minimum of 100 mm). The lake receives less, but more regular, runoff from the smaller, steeper catchments located on its western and eastern shores, and from rainfall directly on the lake surface.

None of the watercourses or drainage lines in the Millipede or Lake Maitland mining areas flow naturally year-round. Clay-pans are common throughout the region, with some hosting surface water for several months of the year. These semi-permanent water bodies provide habitat for local fauna and flora, migratory birds and some have cultural heritage significance. Local and regional surface water bodies, whether occurring on clay-pans or salt lakes, are naturally brackish to saline.

The palaeodrainage systems transmit ground and surface water along the catchment in which the proposed mining operations are located. The palaeodrainage systems once allowed free flow of surface runoff as far as the Eucla Basin (millions of years ago), but now are low gradient, low energy systems. They are characterised by the occurrence of salt lakes, some in chains and some isolated, that typically act as local drainages, where water from higher in the catchment is lost through evaporation. Occasional major rain events originating as cyclones may fill the local drainages, allowing flow to move further down the drainage system. Occasional large storms, notably Cyclone Bobby in February 1995, generate sufficient runoff to fill some lakes and then to flow down the drainage. The wettest period in the Wiluna rainfall record occurred from December 1941 to May 1942 when 732 mm fell in six months. This period constituted about a 1-in-200 years to 1-in-500 years wet season, but did not result in water flowing from Lake Way to Lake Maitland. Consequently, it is considered that a much larger, extremely rare rain event would be required to initiate overtopping of Lake Way towards Lake Maitland.

Both Lake Way and Lake Maitland are low points in the landscape and have shallow water tables. They act as groundwater discharge zones by direct evaporation from their surfaces. Salt therefore accumulates, both at the surface of the lake beds and as underlying brines. Lake Way and Lake Maitland are mostly characterised by underlying brines rather than a permanent salt crust, although salt crusts of varying thickness are present over parts of Lake Way.

The catchment area between Wiluna and Lake Maitland has an overall area of about 15,000 sq km with elevations varying from around 470 mAHD in the vicinity of Lake Maitland to around 595 mAHD in the upper reaches north of Wiluna. About 70% of the overall catchment, almost 11,000 sq km, lies upslope of Lake Way which has a storage capacity of about 700 Mm^3 at the point of overflow to the downstream catchment. The intervening catchment between Lake Way and Lake Maitland has an area of about 4300 sq km. General surface slopes are extremely low at less than 0.06% over the majority of the catchment, reducing to less than 0.05% in the proposed mining area at Lake Maitland.

Intermittent surface water flows occur after heavy falls normally associated with cyclonic rains, which typically occur in the months of January to March. Dewatering discharges from existing and historic mining operations in the northern part of Lake Way have for some years caused more or less continuous surface discharge of water to Lake Way. Flow within the natural drainage system only occurs following larger storm events, typically corresponding to catchment wide rainfall depths in the order of 60 mm or greater, which only occur about once in every 5 to 10 years (Table 13.2). This reflects the low and infrequent rainfalls in the region, high evaporation, low catchment slopes and high infiltration capacity of the surface soils. At Lake Maitland, surface water flow is likely to be negligible for storms having a magnitude less than the 1-in-10 year event: for catchment wide storms delivering less than about 60 mm of rain there may be local ponding in low-lying depressions, but this would not result in flow along creek lines.

Table 13.2: Point rainfall depths (mm) for various storm durations – Lake Way and Lake Maitland

Storm Duration (h)	100 Year ARI	500 Year ARI	1000 Year ARI	PMP Event
24	167	188	226	780
36	189	215	239	920
48	204	237	262	1050
96	223	266	294	1280
120	250	272	300	1450

Note: ARI – average recurrence interval; PMP Event – Probable Maximum Precipitation event: it is the theoretical maximum precipitation for a given rainfall duration under modern meteorological conditions. Results are summarised from Golder (2011e). The values shown were calculated using the CRC Forge method for Western Australia. The PMP event corresponds to a return interval of about 1-in-10,000 years. For context, the last glacial period in Australia ended about 11,700 years ago.

When evaluating design floods, point rainfall estimates must be adjusted to reflect rainfall distributed over the catchment upstream of the site of interest. The depth of rain estimated over the whole of the catchment is typically smaller than the point estimate, as it would rarely be the case that rain occurs at the same intensity over the whole of a catchment. The Bureau of Meteorology assumes that storm durations of 12 hours or less represent 'localised' storm events affecting an area of no more than 1000 sq km. For longer duration events (24 hours or longer), storms are assumed to extend over a larger area, for example the entire catchment between Lake Way and Lake Maitland. Table 13.3 summarises the 'point' and 'catchment scale' design storm depths for the Project area (RPS, 2015a – Appendix 10.1).

Table 13.3: Point and catchment design rainfall depth (mm) estimates – various durations and return intervals

	10 Year		20 Year		100 Year		500 Year		1000 Year	
Duration (h)	Pt	Cat	Pt	Cat	Pt	Cat	Pt	Cat	Pt	Cat
'Localised' Storms (up to 1000 sq km Catchment)										
1	29	24	34	29	48	41	--	--	--	--
2	37	31	45	38	64	55	--	--	--	--
6	55	46	68	58	101	86	--	--	--	--
12	70	60	88	75	133	113	150	128	180	153
Catchment Between Lake Way and Lake Maitland (4300 sq km)										
24	87	57	109	71	167	109	188	122	226	147
36	98	64	123	80	189	123	215	140	239	156
48	106	69	133	87	204	133	237	154	262	171
72	115	75	145	94	223	145	256	167	283	185
96	124	81	156	102	250	163	266	173	294	191

Note: Pt – a point estimate; Cat – a catchment estimate; '--' – no estimate was made.

Surface Water Quality – Millipede

Limited surface water quality information is available for Millipede as runoff from the surrounding catchment which would result in streamflow and ponding of water at or near the deposit is a relatively rare event, occurring on average no more than about once in every five years.

Water quality in salt lakes and the lower tributaries that discharge to the lakes is influenced by a number of factors including local geology, sediment chemistry, wind-induced water movement, antecedent rainfall conditions and the timing of sampling within the hydro-period. In general, major storm events, such as the flows associated with Cyclone Bobby, would result in the formation of a large freshwater or brackish surface water body which would become increasingly saline over time as a result of evaporative concentration.

As part of baseline investigations for the Wiluna Project, Toro commissioned a review of available surface water quality results for West Creek and Lake Way collected between 1998 and 2006 (Table 13.4).

The background surface water quality at Lake Way (when present) is generally saline or hypersaline and dominated by sodium, chloride and (to a lesser degree) sulphate. The pH values reported for water on the playa and in the West Creek tributary vary from moderately acidic to alkaline. Some of the background concentrations reported for trace elements are unexpectedly high (see, for example reported concentrations of copper, nickel, lead, arsenic and zinc). Although the review found that the water samples were not taken at a time when discharges from the Apex Gold Mine were occurring, it is possible that some of the results are influenced by historic discharges to Lake Way from upstream mining operations or other upstream sources (Aquaterra, 2010b).

Table 13.4: Background surface water quality – Lake Way and West Creek

Parameter	Units	Lake Way Playa			West Creek Surface Water		
		Range	Upper Quartile	No. of Samples	Range	Upper Quartile	No. of Samples
pH	pH units	5.6–8.82	7.15	10	6.8–9.6	6.95	2
Total dissolved solids	mg/L	10560–229800	184250	10	2700–260000	105000	2
Calcium	mg/L	454–1100	1045	10	740–860	830	2
Chloride	mg/L	28500–85800	72325	10	1015000–69000	55500	2
Magnesium	mg/L	1040–6120	4963	10	–	–	0
Potassium	mg/L	1500–6300	5165	10	–	–	0
Sodium	mg/L	13500–54400	48650	10	–	–	0
Sulphate	mg/L	11000–15700	15400	10	–	–	0
Total N	mg/L	4.8–18.8	14.1	5	–	–	0
Total P	mg/L	0.14–2.6	0.52	5	–	–	0
Arsenic	mg/L	BD–0.63	0.018	9	BD–2.76	0.60	28
Boron	mg/L	0.11–9.41	1.3	13	0.1–37.17	17.5	47
Barium	mg/L	0.07–0.089	0.07	2	–	–	0
Cadmium	mg/L	BD–0.04	0.025	18	BD–1.1	0.025	47
Cobalt	mg/L	BD	BD	13	BD–9.96	0.25	47
Chromium	mg/L	BD–0.25	0.25	18	BD–0.49	0.25	47
Copper	mg/L	BD–0.25	0.025	18	BD–0.9	0.25	47
Iron	mg/L	BD	0.05	5	–	–	0
Manganese	mg/L	BD–0.482	0.25	18	BD–3.68	0.25	47
Nickel	mg/L	BD–0.5	0.25	18	BD–4.4	0.25	47
Lead	mg/L	BD–0.27	0.25	18	BD–13	0.25	47
Selenium	mg/L	BD–0.18	0.052	18	BD–1.722	0.1	47
Uranium	mg/L	BD–0.015	0.005	2	–	–	0
Zinc	mg/L	BD–0.7	0.25	13	BD–1	0.25	47

Source: Outback Ecology, 2010g
Note: BD – below the analytical limit of reporting.

13.4.2 Groundwater – Millipede

In the proposed mining area, subsurface flow occurs within several distinct geological units, of which the calcretes are by far the most conductive. The permeability within the calcretes arises from secondary porosity, with flow occurring through solution vughs and cavities. The permeable zones within the calcretes are generally horizontal to sub-horizontal and are intercalated with silty and clayey units of lower permeability.

The palaeochannel deposits within which the ore body occurs consist of very fine- to coarse-grained quartz sand with minor silt, gravel and carbonaceous horizons. The materials within and underlying the ore zone comprise a sequence of earthy calcrete, siltstone, sand and clay associated with the Quaternary drainage systems.

The uppermost water bearing layers in the Millipede area are part of the Carey palaeodrainage system, which flows from north-west to south-east (Johnson *et al.,* 1999).

Under dry conditions, evaporation from the bed of Lake Way induces water movement to the surface resulting in groundwater discharge from the lake in the form of evaporation. However, given the 30 m elevation gradient to Lake Maitland, it is likely that some subsurface groundwater flow to the south-east also occurs, particularly when elevated water levels occur following extreme rainfall events.

In the proposed mining area, the groundwater table is typically 2 m to 5 m below the surface and the depth to water generally reduces with proximity to Lake Way.

Groundwater beneath the proposed mine is hypersaline (more than three times as saline as seawater), with a neutral to slightly alkaline pH. Both uranium and vanadium are naturally elevated, reflecting the mineralised character of the area (Table 13.5).

Table 13.5: Millipede groundwater chemistry

Parameter		Unit	Mean
pH		pH units	7.2
Conductivity	EC	mS/cm	103
Total Dissolved Solids	TDS	mg/L	122,664
Soluble iron	Fe	mg/L	<0.1
Sodium	Na	mg/L	35,380
Potassium	K	mg/L	2443
Calcium	Ca	mg/L	320
Magnesium	Mg	mg/L	3981
Chloride	Cl	mg/L	53,195
Carbonate	CO_3	mg/L	<1
Bicarbonate	HCO_3	mg/L	154
Sulphate	SO_4	mg/L	14,103
Uranium	U	mg/L	0.06
Vanadium	V	mg/L	0.04

Note: Data in table represent the results of 14 water samples recovered in January 2012.

A public drinking water source protection area (the water supply for the Town of Wiluna) lies approximately 7 km east of Wiluna (Water Corporation, 2004). The water source protection area, which is equipped with two shallow production wells that draw water from an unconfined calcrete aquifer, lies approximately 25 km north-north-west (up hydraulic gradient) of the Millipede deposit. The Wiluna town water supply is up-gradient of Toro’s proposed mining and processing areas and not hydraulically connected to them. There is no plausible scenario under which groundwater from the vicinity of mining at Millipede could flow towards the town water supply.

13.4.3 Lake Ecology – Millipede

The Millipede deposit lies to the west (inland) of the Centipede operations area. Only the northern-most edge of the Millipede tenement directly abuts the western shore of Lake Way. The lake edge environment is characterised by alluvial flats grading to low rise kopi dunes (Figure 13.1).

Figure 13.1: View of Lake Way edge, looking south towards the Millipede deposit

Shallow lake sediments near the north end of the Millipede deposit are generally fine grained, with a thin salt crust. The sediments are alkaline in reaction and extremely saline. Trace elements are not noticeably enriched. Organic carbon levels are moderately low (Table 13.6). Black, rugose biological soil crusts were observed on low rise dunes associated with *Tecticornia* communities, but no crusts were apparent on the lake beaches. The main component of the crusts was the filamentous cyanobacterium *Microcoleus chthonoplastes* which has been found to be the dominant species in crusts from other salt lakes in Western Australia (Campagna, 2007). It is also the major component of rugose crusts in other parts of Australia (Ullman and Budel, 2003) and globally (Johansen *et al.,* 2001).

Table 13.6: Lake Way – shallow sediment chemistry near Millipede

	Units	Range
pH	pH units	8.0–8.4
Electrical conductivity	µS/cm	24,200–34,000
Total soluble salts	mg/kg	78,600–110,000
Chloride	mg/kg	6120–51,200
Bicarbonate	mg/kg	<1–2
Carbonate	mg/kg	<1
Sodium	mg/kg	40,500–51,800
Calcium	mg/kg	39,500–84,200
Magnesium	mg/kg	7490–18,300
Potassium	mg/kg	4100–5390
Total nitrogen	mg/kg	250–640
Total phosphorus	mg/kg	69–139
Total organic carbon	%	0.22–0.37
Aluminium	mg/kg	2320–8380
Arsenic	mg/kg	5–12

	Units	Range
Barium	mg/kg	<10–10
Boron	mg/kg	<50–50
Cadmium	mg/kg	<1
Chromium	mg/kg	34–73
Cobalt	mg/kg	< 2–5
Copper	mg/kg	6–19
Iron	mg/kg	7580–19,200
Lead	mg/kg	<5
Manganese	mg/kg	53–94
Nickel	mg/kg	6–20
Uranium	mg/kg	2–7
Zinc	mg/kg	6–20

Note: Results represent analysis of three samples, all of which were recovered from a depth of 0–20 mm.

Overall, the Millipede Project area was assessed as having a moderately diverse aquatic community, although the diversity is low compared to smaller and less saline wetlands. The diversity and nature of taxa identified are characteristic of lakes in the Goldfields region (Outback Ecology, 2008b). Generally, there was a low diversity and abundance of diatoms, compared to previous studies on other lakes from this region.

The diversity of resting stages observed in the Project area was similar to that of other large playas and the same array of taxa was recorded from the sediment as from other lakes in the vicinity. The invertebrate taxa were halobiont species dominated by the ostracods and *Parartemia* sp. d. This is an endemic brine shrimp that has a distribution range from Lake Way through to Lake Carey and south to Lake Yindarlgooda. An examination of resting stages of invertebrates, algae and higher plants in lake sediments near the Millipede/Centipede deposits found no invertebrate taxa that could be identified as restricted to Lake Way.

13.5 Existing Environment – Lake Maitland

13.5.1 Surface Water Quality – Lake Maitland

No surface water sampling has been possible at Lake Maitland since Toro acquired the project from Mega Uranium. On the two occasions when there has been sufficient rainfall to generate surface flow (January 2014 and March 2015), the ground conditions near the lake were not trafficable. In lieu of surface water results, Toro has had to rely on water quality data for shallow groundwater samples taken from ten costeans (trenches) excavated at Lake Maitland in late 2009. The trenches were excavated to depths ranging from 4.0 m to 5.5 m and were left to equilibrate for at least two days. Water samples were then recovered from depths ranging from 1.5 m to 3.5 m. Results are summarised in Table 13.7. Overall, the costean water quality results are similar to the results observed in deeper groundwater samples (taken from depths ranging from 4.5 m to 16 m).

The shallow water quality results show that near-surface water at Lake Maitland is saline to hypersaline, well oxygenated, and dominated by sodium and chloride. The major ion composition is similar to seawater. Trace metal and metalloid concentrations in shallow groundwater at Lake Maitland are generally low, although dissolved uranium was measured at concentrations up to 0.18 mg/L.

Table 13.7: Costean water quality (November 2009) – Lake Maitland

Parameter	Unit	Range	No. of Samples
pH		7.21–7.61	10
Electrical Conductivity	mS/cm	64.7–151.0	10
Total Suspended Solids	mg/L	38–104	10
Total Dissolved Solids	mg/L	53,600–159,000	10
Total Alkalinity (as $CaCO_3$)	mg/L	40–180	10
Chloride	mg/L	25,600–74,600	10
Sulphate	mg/L	6690–13,800	10
Sodium	mg/L	14,200–38,100	10
Calcium	mg/L	619–1080	10
Magnesium	mg/L	1400–4640	10
Potassium	mg/L	951–2970	10
Fluoride	mg/L	0.4–0.7	10
Total Nitrogen as N	mg/L	54.8–117	10
Nitrite-N	mg/L	0.01–0.8	10
Nitrate-N	mg/L	50–111	10
Ammonia-N	mg/L	0.1–0.22	10
Total Kjeldahl-N	mg/L	2.2–8.1	10
Reactive Phosphorus as P	mg/L	0.01–0.02	10
Total Organic Carbon	mg/L	4–9	10
Aluminium	mg/L	<0.1	10
Antimony	mg/L	<0.01	10
Arsenic	mg/L	<0.01–0.01	10
Barium	mg/L	0.011–0.033	10
Boron	mg/L	8.42–13.3	10
Cadmium	mg/L	<0.001	10
Chromium	mg/L	<0.01	10
Cobalt	mg/L	<0.01	10
Copper	mg/L	0.017–0.09	10
Iron	mg/L	<0.5	10
Lead	mg/L	<0.01	10
Manganese	mg/L	<0,01–0.223	10
Molybdenum	mg/L	<0.03–0.087	10
Nickel	mg/L	<0.01–0.012	10
Selenium	mg/L	<0.1–0.15	10
Thorium	mg/L	<0.001	10

Parameter	Unit	Range	No. of Samples
Uranium	mg/L	0.011–0.183	10
Vanadium	mg/L	<0.1–0.1	10
Zinc	mg/L	<0.05	10

Source: Data are summarised from Golder Associates (2011d).
Note: All trace element results are for dissolved metals.

13.5.2 Groundwater – Lake Maitland

The sediments of the Carey palaeodrainage in which Lake Maitland lies comprise basal sands and the overlying Cainozoic sediments consist of an inter-bedded sequence of dense, plastic clays with occasional sand lenses overlain by alluvial sands. Shallow alluvium and colluvium occur throughout the region with calcrete occurring at the margins of present day salt lakes, and locally in some of the tributaries of the main drainages. The surficial calcrete (calcrete tongue and other local and regional outcrops) was precipitated from calcium-carbonate saturated groundwater and occurs as a discrete aquifer flanking the palaeodrainage, overlying sandy clay alluvial sediments. Groundwater flows from higher ground that is underlain by variably weathered bedrock and discharges into the main aquifers located in the palaeodrainage system. The Lake Maitland playa lake system functions as an (evaporative) discharge area.

In the proposed Lake Maitland operations area, four broad aquifer types have been identified:

- Shallow alluvium;
- Calcrete;
- Palaeochannel; and
- Fractured rock.

The shallow alluvial aquifers generally have a low permeability, but are important localised aquifers. Where present, the calcrete aquifers exhibit secondary permeability caused by chemical dissolution. They can often provide large local fresh to brackish groundwater supplies. The playa lake sediments form minor shallow hypersaline aquifers.

The palaeochannel sand aquifers are confined below dense clay layers, with overlying alluvial/calcrete aquifers in places. Groundwater elevations within the bedrock aquifer are typically higher than those within the palaeodrainage aquifers. The palaeochannel sand is typically permeable and locally capable of containing significant supplies of groundwater (fresh to brackish in the tributaries and saline to hypersaline in the main trunk of the drainage). The palaeochannel sands, however, can have limited storage with most long-term groundwater supplies being derived from induced leakage from overlying clays and the surrounding fractured rock aquifers.

The fractured basement rocks are characterised by secondary porosity and permeability, and form localised aquifers.

Groundwater quality near the Lake Maitland deposit is saline to hypersaline, with salinities ranging from 62,800 mg/L (nearly twice the salinity of seawater) to 250,000 mg/L (more than seven times the salinity of seawater). The high salinity reflects the high evaporative regime in the area, as well as the long residence time of water passing through the palaeovalley systems. The dominant ions are sodium and chloride, occasionally with minor amounts of magnesium and sulphate. The groundwater pH is generally neutral to slightly acidic (Golder Associates, 2011d – Appendix 10.53).

The maximum dissolved uranium concentration observed during baseline studies was 0.16 mg/L. Vanadium, molybdenum and selenium occasionally are present in relatively high concentrations (Table 13.8). The groundwater is generally low in oxygen, indicating a reducing subsurface environment.

Table 13.8: Lake Maitland groundwater chemistry

Parameter	Unit	Range (Mining Area)	No. of Samples (Mining Area)	Range (Borefield)	No. of Samples (Borefield)
pH		6.13–7.54	70	6.9–8.2	21
Electrical Conductivity	µS/cm	62,800–220,500	71	1200–340,000	21
Total Suspended Solids	mg/L	5–2600	85	–	
Total Dissolved Solids	mg/L	62800–250,000	85	760–210,000	21
Total Alkalinity (as $CaCO_3$)	mg/L	39–170	78	77–140	6
Chloride	mg/L	26,400–108,000	79	200–100,000	21
Sulphate	mg/L	7410–28,800	86	71–20,000	21
Bicarbonate	mg/L	40–160	47	94–430	21
Sodium	mg/L	17,900–67,100	86	120–70,000	21
Calcium	mg/L	620–1340	86	42–1000	21
Magnesium	mg/L	1590–7350	84	31–7800	21
Potassium	mg/L	480–5940	86	13–5200	21
Bromide	mg/L	2.86–25	86	–	
Fluoride	mg/L	0.2–0.8	81	0.5–1.7	21
Total Nitrogen as N	mg/L	28.7–120	82	–	
Nitrite-N	mg/L	<0.01–16.8	81	–	
Nitrate-N	mg/L	25.4–113	79	21–210	21
Ammonia-N	mg/L	<0.036–3.52	79	–	
Total Kjeldahl-N	mg/L	<0.5–21.4	75	–	
Reactive Phosphorus as P	mg/L	<0.01–0.09	79	–	
Total Organic Carbon	mg/L	2–29	84	–	
Aluminium	mg/L	<0.008–0.26	86	–	
Antimony	mg/L	<0.001–0.01	86	–	
Arsenic	mg/L	<0.005–0.16	86	–	
Barium	mg/L	<0.01–0.258	86	–	
Boron	mg/L	2.86–24	86	–	
Cadmium	mg/L	<0.001–0.017	86	–	
Chromium	mg/L	<0.001–0.1	86	–	
Cobalt	mg/L	<0002–0.1	86	–	
Copper	mg/L	<0.002–0.114	86	–	
Iron	mg/L	<0005–2	86	<0.02–0.68	21

Parameter	Unit	Range (Mining Area)	No. of Samples (Mining Area)	Range (Borefield)	No. of Samples (Borefield)
Lead	mg/L	<0.001–<0.1	86	–	
Manganese	mg/L	<0.02–2.93	86	<0.005–4.4	21
Molybdenum	mg/L	<0.02–0.15	86	–	
Nickel	mg/L	<0.01–0.1	86	–	
Selenium	mg/L	<0.061–0.2	86	–	
Thorium	mg/L	<0.001–00.1	83	–	
Uranium	mg/L	<0.008–0.508	86	–	
Vanadium	mg/L	<0.017–0.9	86	–	
Zinc	mg/L	<0.003–0.343	86	–	

Note: All trace element results are for dissolved metals.
Sources: Data for the proposed mining area are from Golder Associates (2011d); Data for the proposed borefield are from RPS Aquaterra (2011).

Groundwater quality near the proposed borefield to the north of Lake Maitland ranges from near-fresh (total dissolved solids of 760 mg/L) to very saline (210,000 mg/L TDS) (RPS 2015c – Appendix 10.62). Groundwater pH values are mostly neutral to slightly alkaline.

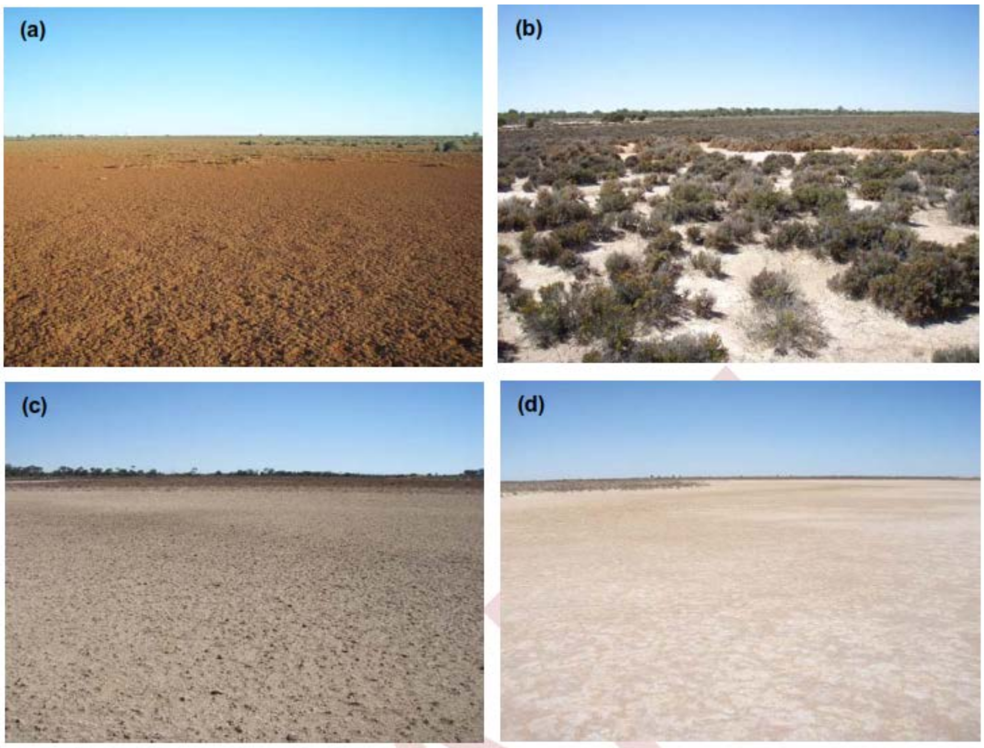
There are three groundwater licences within a 50 km radius of the Project area at Lake Maitland. The nearest are held by the Bronzewing and Mt Keith mining operations. The closest borefield, the Mt Joel Borefield, is located approximately 12 km to the south of the Project area and exploits water from a shallow alluvial and weathered basement aquifer.

There are many pastoral bores in the region. They generally utilise shallow superficial aquifers and usually do not exceed 30 m in depth. Most bores in the vicinity of Lake Maitland are recorded as being in the range of 5 m to 20 m deep, where data is available.

13.5.3 Lake Ecology – Lake Maitland

Baseline aquatic ecology surveys of Lake Maitland (Outback Ecology, 2011a – Appendix 10.14) have identified a variety of habitat types, including floodplains along the playa edge, claypans, playa and evaporite pans (within the playa) (Figure 13.2). The proposed mine operations area at Lake Maitland is mainly characterised by playa habitat.

Figure 13.2: Lake Maitland habitats: (a) Claypan, (b) Floodplain, (c) Evaporite Pan, (d) Playa



The shallow sediments within the Lake Maitland playa are alkaline and saline, with generally low trace element concentrations and low to moderate organic carbon (Table 13.9). Uranium concentrations vary, but frequently exceed the published average global crustal abundance value for uranium (2.4 mg/kg (Bowen, 1979)) by up to an order of magnitude in sediments overlying the ore body and in parts of the lake downstream of the ore body. Sediments upstream of the ore body tend to be somewhat less saline and lower in uranium, but are not necessarily lower in other trace metals (for example, thorium).

Table 13.9: Lake Maitland – shallow sediment chemistry

	Units	North End of Lake	Centre Lake (Ore Body)	South End of Lake
pH		6.0–8.9 (7.8)	7.4–8.7 (8.3)	7.5–9.0 (8.4)
Electrical Conductivity	µS/cm	8–21700 (4595)	4360–28900 (10983)	2820–43500 (16371)
Total Soluble Salts	mg/kg	26–70500 (14930)	14200–93900 (35690)	9160–141000 (53208)
Total organic carbon	%	BD–0.4 (0.2)	0.1- 0.4 (0.2)	BD–1.0 (0.2)
Chloride	mg/kg	BD–36300 (7024)	3320–54400 (17695)	3610–90200 (29976)
Sulphate	mg/kg	BD–37800 (3343)	11000–30900 (16739)	7800–67000 (21699)
Bicarbonate	mg/kg	3–707 (121)	14–497 (185)	6–533 (121)
Carbonate	mg/kg	BD–31,0 (1.3)	BD–38.0 (5.2)	BD–58.0 (6.4)
Sodium	mg/kg	BD–20400 (4563)	2160–29700 (11230)	2500–81800 (19006)
Calcium	mg/kg	BD–13000 (514)	3580–6140 (4641)	1100–7150 (4860)
Magnesium	mg/kg	BD–3440 (372)	230–2860 (982)	230–4350 (1678)
Potassium	mg/kg	BD–1000 (233)	230–2450 (1092)	290–8150 (1982)
Total Nitrogen	mg/kg	BD–1410 (298)	70–1040 (283)	BD–1390 (259)
Total Kjeldahl N	mg/kg	60–480 (229)	50–590 (213)	BD–900 (206)
Total P	mg/kg	47–139 (95)	44–160 (86)	34–248 (89)
Aluminium	mg/kg	960–13300 (4800)	2590–15900 (4892)	780–4950 (1909)
Arsenic	mg/kg	BD–5.6 (1.1)	BD–12.4 (3.1)	0.1–6.6 (1.1)
Barium	mg/kg	BD–12.6 (4.5)	BD–128 (12.7)	BD–8.4 (1.6)
Boron	mg/kg	BD–160 (32.8)	50.1–419 (155.9)	BD–208 (61)
Cadmium	mg/kg	All BD (BD)	All BD (BD)	BD–0.2 (BD)
Chromium	mg/kg	BD–53.8 (28.5)	BD–25.8 (13.2)	3.8–36.7 (15.3)
Cobalt	mg/kg	BD–3.3 (1.3)	BD–3.0 (1.1)	0.4–2.8 (1.0)
Copper	mg/kg	BD–9.1 (3.5)	BD–8.4 (2.0)	BD–7.9 (2.2)
Iron	mg/kg	4370–16700 (10212)	3030–14200 (5000)	2540–11200 (4837)
Lead	mg/kg	BD–5.4 (2.6)	BD–3.8 (0.7)	BD–3.2 (0.9)
Manganese	mg/kg	BD–200 (67.4)	BD–146 (47.4)	7.6–133.0 (37.0)
Nickel	mg/kg	BD- 7.6 (2.6)	BD–6.0 (1.9)	BD–5.5 (1.5)
Thorium	mg/kg	BD- 4.8 (1.8)	BD–2.9 (0.6)	BD–3.5 (0.8)
Uranium	mg/kg	BD- 7.7 (1.3)	BD–44.2 (16.2)	0.8–26.0 (6.0)
Vanadium	mg/kg	BD–42 (18.0)	BD–102 (28)	4.0–28.0 (11.5)
Zinc	mg/kg	BD–23.8 (6.3)	BD–15 (5)	BD–14.4 (2.9)
No. of Samples Tested		72	72	108

Source: Results are summarised from Outback Ecology (2011h).
Note: All samples were recovered from a depth of 0–30 mm.

Hydrogeological processes and morphological characteristics have a strong influence on the biota of Lake Maitland. The taxa found can withstand elevated salinities and exhibit short lifecycles; adaptations which allow them to survive in temporary aquatic environments. The majority of the productivity appears to be confined to the southern area of the lake, where water appears to be held for longer periods following substantial rainfall. Elevated sites in the north-west arm of the lake were relatively devoid of biota by comparison, likely associated with poor sediment structure.

The aquatic baseline assessment of Lake Maitland showed that the biological productivity was higher at the southern end of the lake (downstream of the ore body), where water is likely to be held for longer periods during flood, due to the lake topography and surrounding drainage patterns. The northern end of the lake was described as having limited water retention capacity and has been heavily impacted by cattle, which have caused sediment disturbance, resulting in the restricted colonisation of biota.

The resident biota of Lake Maitland are characteristic of many inland lakes in Western Australia and comprise salt tolerant algae, macrophytes and invertebrates (Table 13.10). The organisms observed at Lake Maitland are also known to occur more widely in the region, having been recorded from Lake Carey, Lake Miranda and Lake Way. This reflects dispersal along the Carey palaeochannel via waterbirds and potentially through the occasional connectivity of habitat that occurs during extreme flood events.

Table 13.10: Salt Lake biota – regional summary

Taxa	Centipede/ Millipede	Lake Maitland	Lake Miranda	Lake Carey
Crustacea				
Anostraca				
Branchinella simplex	✓	✓	✓	✓
Parartemia laticaudata sp. nov.	✓	✓	✓	✓
Parartemia veronicae sp. nov.				
Parartemia bicorna sp. nov.				✓
Ostracoda				
'Dragoncypris outbacki' n. gen. n. sp.	✓	✓	✓	✓
Repandocypris austinensis		✓	✓	✓
Conchostraca				
Eocyzicus parooensis		✓		
Algae				
Characeae (Charophyta)				
Lamprothamnium cf. *macropogon*	✓	✓	✓	
Nitella sp.	✓	✓	✓	
Magnoliphyta (Flowering plants)				
Ruppiaceae				
Ruppia sp.	✓	✓	✓	

Source: Outback Ecology (2011a)

The taxa found at Lake Maitland can withstand elevated salinities and exhibit short lifecycles; adaptations which allow them to survive in temporary aquatic environments. All of the biological communities identified from Lake Maitland are also known to persist in temporary environments as dormant stages or resting spores, emerging only when conditions are suitable (Moscatello and Belmonte, 2009).

Many of the algal and invertebrate taxa recorded at Lake Maitland were classified as euryhaline, having a broad salinity tolerance, and able to withstand elevated surface water salinities. The biota inhabiting these temporary aquatic environments are well-adapted to saline conditions, and can rapidly colonise the lake after a filling event (Boulton and Brock, 1999; John, 2001). Many of them also have short lifecycles that allow them to reproduce while the system is less saline (McComb and Lake, 1990). Others can persist in hypersaline waters until the final stages of the filling phase, taking advantage of rare inundation opportunities (Smith *et al.,* 2004).

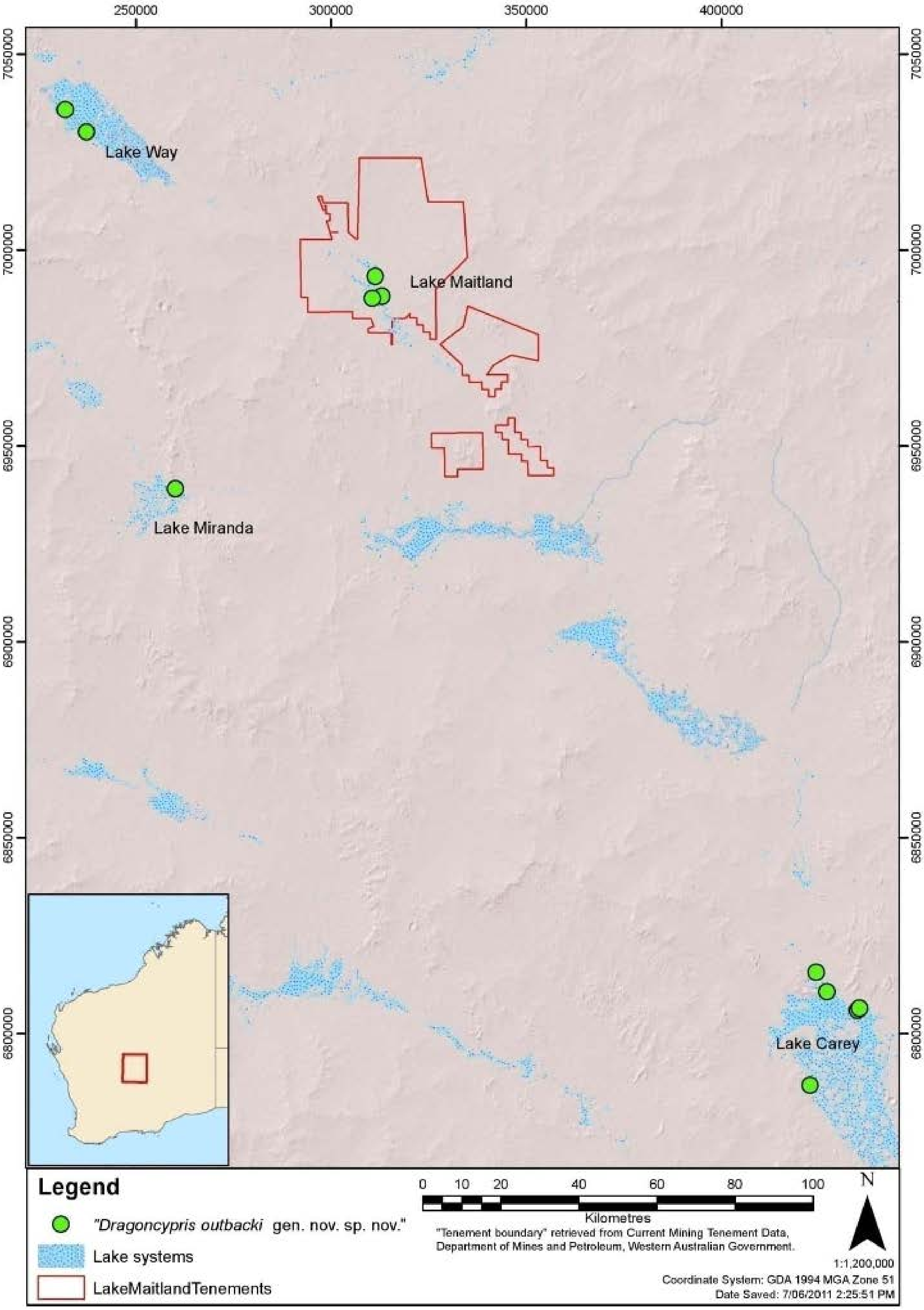
Sediment rewetting trials were conducted to observe changes to sediment biota following the addition of water (to simulate a lake-fill event). The key outcomes of rewetting trials were that:

- Rewetted samples showed the soil biological crusts were dominated by cyanobacteria which have a number of ecological functions including water retention, nitrogen cycling and soil stabilisation; and
- A new genus of ostracod was reared from sediment collected from three sites; it was identified as *Dragonsypris outbaki* nova gen. nova sp. (I. Karanovic) (Crustacea).

The risk to *Dragonsypris outbaki* from the Proposal is very low. Studies were completed to identify its distribution range. Specimens have been found outside the area where mining would occur and in three other lakes in the Carey palaeodrainage system (Figure 13.3).

None of the biota identified during baseline investigations at Lake Maitland are listed as rare or threatened, and all were shown to have a widespread regional distribution.

Figure 13.3: Regional distribution of '*Dragoncypris outbacki*' gen. nov. sp. nov.



13.6 Potential Impacts

The potential impacts on inland waters from implementing activities proposed under the extension of the Wiluna Uranium Project are summarised in Table 13.11.

Table 13.11: Inland Waters – Aspects, Impacts and Mitigation

Aspect	Potential Impacts	Proposed Mitigation
Millipede: encroachment of mine footprint on drainage lines	Backwater effects: increased depth or duration of flooding upstream of mine	Mining would be conducted progressively (in panels) to limit the scale of disruption to surface flows. Diversion channels would be provided to direct creek flow around active mining panels and return the water to the natural drainage system. Once mining has been completed and pits have been backfilled the natural flow geometry would be restored.
	Modified flow velocity during flow events:risk of increase erosion	Hydraulic modelling (RPS, 2015a – Appendix 10.1) has concluded that the relatively small scale of development, coupled with the generally flat terrain, would not generate high flow velocities near Millipede. Conventional erosion protection measures should be sufficient to limit erosion of diversion drains and flood protection bunds.
	Disturbance of riparian vegetation and ecosystems	Diversion channels would be provided to maintain flows and prevent impacts on vegetation that could result from greater depth or duration of flooding.
Millipede: flooding of mine pits during operational life of mine	Inundation of mine workings: risk to people and machinery	Flood protection bunds would be established and maintained throughout operations to meet DMP guidelines and any additional flood protection requirements arising from state or federal approvals.
	Inundation of disturbed areas: risk of sediment entrainment	Bulk earthworks during the construction phase of the project would be scheduled to occur outside the summer rainfall season (January to March). Best practice erosion and sediment control practices would be adopted during construction and operations.
	Inundation of stockpiles of mineralised materials: risk of entrainment	Stockpiles of mineralised materials would be stored on an engineered pad, surrounded by a perimeter catch drain. Any runoff or throughflow contacting the stockpile would be directed to a sediment detention pond.
Millipede: flooding of mined area post closure	Erosion hazard to tailings cover system: risk of loss of containment and release of cover materials and/or tailings to the environment.	Pits would be progressively backfilled and capped with an erosion-resistant cover. Flood protection bunds would be removed as part of site decommissioning works.
Millipede: mine dewatering	Groundwater drawdown reduces habitat available to subterranean fauna	Low permeability perimeter barriers; Mining in panels, with progressive backfilling
	Groundwater drawdown results in modified soil - water relations in vadose zone and affects health of groundwater dependent vegetation	

Aspect	Potential Impacts	Proposed Mitigation
Millipede: In-pit tailings storage	Seepage of tailings constituents to groundwater results in altered groundwater quality	Engineered containment system, including low permeability base and cover system to limit water influx
	Entrainment of sediment or tailings in the event of flooding of mine pits results in discharge of contaminated water or sediment to Lake Way	Flood control bunding and drainage system engineered to exclude the probable maximum flood event
West Creek: extended duration of water abstraction from West Creek borefield	Groundwater drawdown reduces habitat available to subterranean fauna	Diversification of water supply (Lake Maitland borefield); careful control and adaptive management of rate of water abstraction.
	Groundwater drawdown reduces water available to groundwater dependent vegetation	
Lake Maitland: encroachment of mine footprint on lake surface and drainage lines	Backwater effects: increased depth or duration of flooding upstream of mine	During detailed design, Toro will review its mining schedule and seek to minimise backwater effects through adjustment to the layout and timing of mining panels.
	Modified flow velocity during flow events:risk of increase erosion	Surface water diversion drains and flood protection bunds would be designed and constructed to take account of the predicted increase in flow velocity. At closure, flood protection bunds would be removed and the land surface recontoured and rehabilitated to restore pre-mining flow paths.
	Disturbance of riparian vegetation and ecosystems	During detailed design, Toro will review its mining schedule and seek to minimise backwater effects through adjustment to the layout and timing of mining panels.
Lake Maitland: flooding of mine pits and/or haul road during construction/development or during the operational life of mine	Inundation of mine workings: risk to people and machinery	Flood protection bunds would be established and maintained throughout operations to meet DMP guidelines and any additional flood protection requirements arising from state or federal approvals.
	Inundation of disturbed areas: risk of sediment entrainment	Bulk earthworks during the construction phase of the project would be scheduled to occur outside the summer rainfall season (January to March). Best practice erosion and sediment control practices would be adopted during construction and operations.
	Inundation of stockpiles of mineralised materials: risk of entrainment	Stockpiles of mineralised materials would be stored on an engineered pad, surrounded by a perimeter catch drain. Any runoff or throughflow contacting the stockpile would be directed to a sediment detention pond

Aspect	Potential Impacts	Proposed Mitigation
Haul road development	Altered depth, frequency or duration of flooding upstream and downstream of haul road as a result of impeding surface water flows: potential impacts on vegetation.	At locations where the haul road crosses existing drainage lines, the road would be designed as a low level floodway, with culverts to maintain water flow and downstream erosion protection to prevent scour.
Lake Maitland borefield	Groundwater drawdown reduces water available to existing pastoral groundwater users	Careful control and adaptive management of rate of water abstraction; Commitment to provide alternative water supply to existing groundwater users if required
Lake Maitland: mine dewatering	Groundwater drawdown reduces habitat available to subterranean fauna	Low permeability perimeter barriers; Mining in panels, with progressive backfilling; reinjection of surplus water
	Groundwater drawdown results in modified soil - water relations in vadose zone and affects health of groundwater dependent vegetation	
Lake Maitland: storage and transfer of saline water	Saline water from pit dewatering is accidentally released to lake or surface soil, resulting in salt build up	No planned discharge of saline water to lake surface; Saline water pipelines to be installed within bunds to limit spread of water in the event of a pipe failure; Evaporation ponds provided as contingency in case reinjection system requires maintenance.
Lake Maitland: water reinjection	Mounding of groundwater results in increased salinity in shallow aquifer inhabited by subterranean fauna	Detailed engineering to site and configuration reinjection system to minimise risk of saline water intrusion into lower salinity aquifer; Maximise operational use of saline water from pit dewatering.
	Mounding of groundwater results in 'daylighting' of saline water at lake surface and modified soil-water relations in vadose zone, affecting health of lake edge vegetation	Design and operate distributed reinjection system so as to minimise mounding; Maximise operational use of saline water from pit dewatering.

13.6.1 Flooding of Mine Pits – Millipede

Hydraulic modelling has shown that the Millipede operations area is generally above the 1-in-100 year flood level (RPS, 2015a – Appendix 10.1), but would be flooded to a depth of about 1 m in a Probable Maximum Flood (PMF) event. Notwithstanding the low flood risk, mining areas at Millipede would be surrounded by flood protection bunds to reduce the risk of flooding of active mining areas (potentially resulting in adverse impacts to human safety and/or infrastructure). During active mining operations, the exclusion of flood waters is also necessary to ensure that tailings or supernatant waters disposed of in completed mine pits would not be entrained and discharged into the environment.

The risk of flooding must be considered in the context of the duration of mining activity. The longer the period of mining, the more likely it is that a large flood would occur sometime during the life of the mining operation (Table 13.12). For example, there is slightly less than a 20% chance that a 1-in-100 year flood would occur once during the life of a 20-year mining operation. At Millipede, no flooding is likely to occur—even in the absence of flood protection bunds—unless the flood event exceeded a 1-in-100 year event.

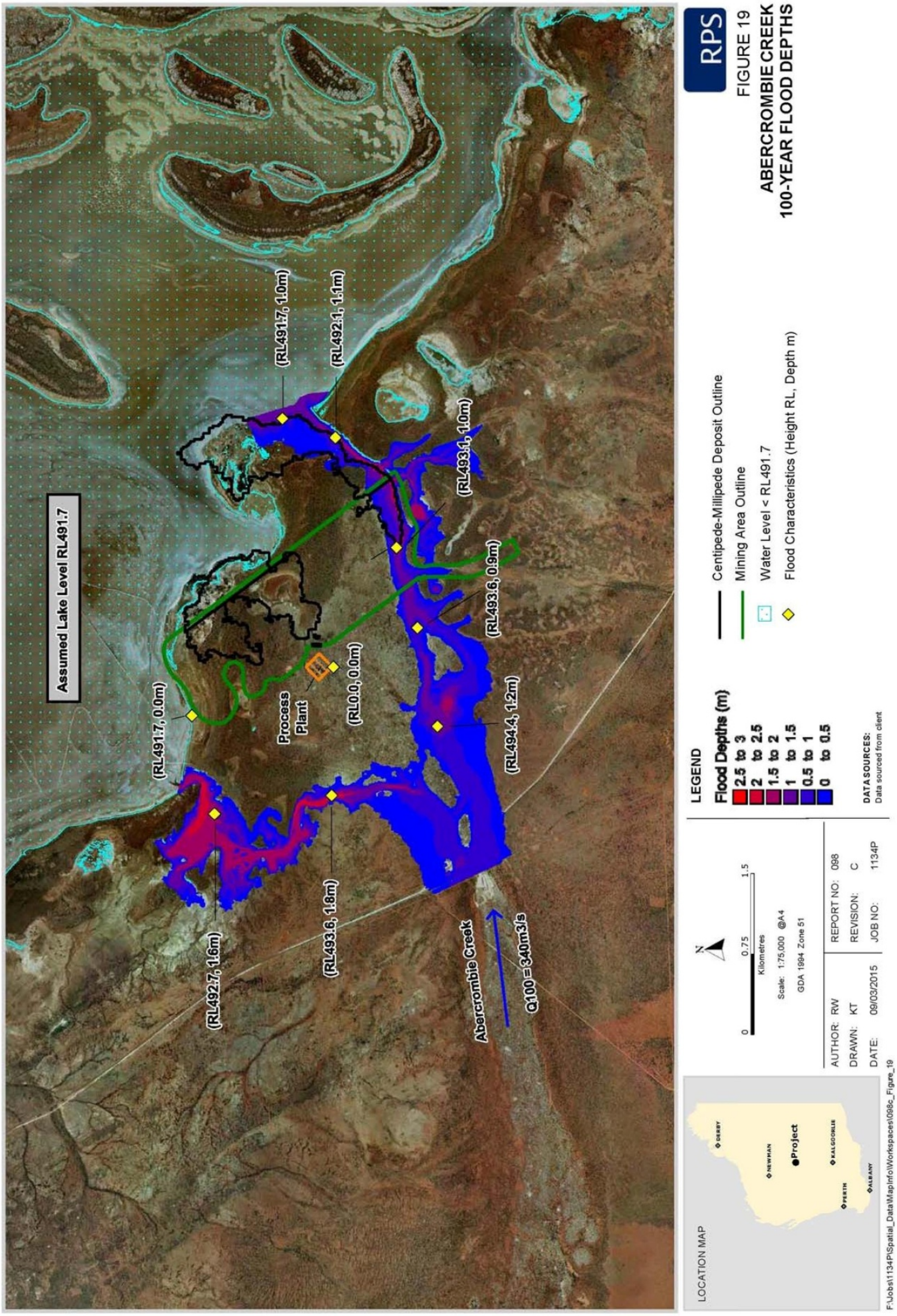
Table 13.12: Probability of flooding (%) – various recurrence intervals and mine life

	Flood Recurrence Interval (ARI, Years)					
Mine Life (Years)	**2**	**5**	**10**	**20**	**50**	**100**
1	39%	18%	10%	5%	2%	1%
3	78%	45%	26%	14%	6%	3%
5	92%	63%	39%	22%	10%	5%
10	99%	86%	63%	39%	18%	10%
15	100%	95%	78%	53%	26%	14%
20	100%	98%	86%	63%	33%	18%

13.6.2 Encroachment of Mine Footprint on Drainage Lines – Millipede

The proposed Millipede operations area lies in the lower reaches of the Abercromby Creek catchment (Figure 13.4). The creek bifurcates at a point about 6 km upstream of the western shore of Lake Way. The two branches of the creek pass to the west and south of the Millipede deposit. Hydraulic modelling of flows along the Abercromby Creek (RPS, 2015a – Appendix 10.1) estimate that about 60% of flows in a 1-in-100 year event pass along the channel to the west of the Millipede area, with the remaining flow passing along the southern channel. During a 1-in-100 year flood, the estimated depth of flow in the natural drainage channels is in the order of 1 m to 1.5 m, with average flow velocities between 0.5 m/s and 0.6 m/s.

Figure 13.4: Abercromby Creek catchment, showing 1-in-100 year flood zone



The proposed mine development at Millipede does not encroach on the Abercromby Creek drainage lines and flood modelling predicts that during a 1-in-100 year flood the Abercromby Creek would not spill into the Millipede operations areas, even in the absence of flood protection bunding. In the absence of flow modifications to allow mining of the Centipede deposit, it is chiefly through the construction of flood protection works that there is a possibility of obstructing flow along the northern channel of Abercromby Creek where it enters Lake Way. It may be possible through detailed design and mine scheduling to reduce changes to hydrological flows along Abercromby Creek, in the event that a significant flood event occurs during the period that active mining and rehabilitation is occurring at Centipede. If no significant flows occur during the active life of the mine, then hydrological changes are likely to be indiscernible. At closure, the creek diversion works at Centipede and flood protection bunds at both Millipede and Centipede would be removed. The land would be recontoured and rehabilitated to approximate pre-mining flow patterns.

13.6.3 Pit Dewatering – Millipede

The potential impacts of mine dewatering have been addressed in detail in the sections of the PER that describe the environmental values (subterranean fauna: Section 12, groundwater dependent vegetation: Section 9) that could be impacted. The predicted drawdown magnitudes and extents at Millipede were estimated using a calibrated hydrogeological model which incorporated a number of conservative assumptions, including:

- No perimeter barriers in place (or barriers ineffective); and
- Full dewatering required throughout the period of pit backfilling.

Over 170 groundwater bores, including both local and regional bores, were used to calibrate the steady state model. The agreement between measured and predicted water levels was generally good (Figure 13.5). Figure 13.6 shows the distribution of bores within a nominal 5 km radius of the Millipede/Centipede deposit that were used in calibrating the groundwater model.

Figure 13.5: Measured and modelled groundwater levels – Millipede/Centipede (RPS, 2015b – Appendix 10.56)

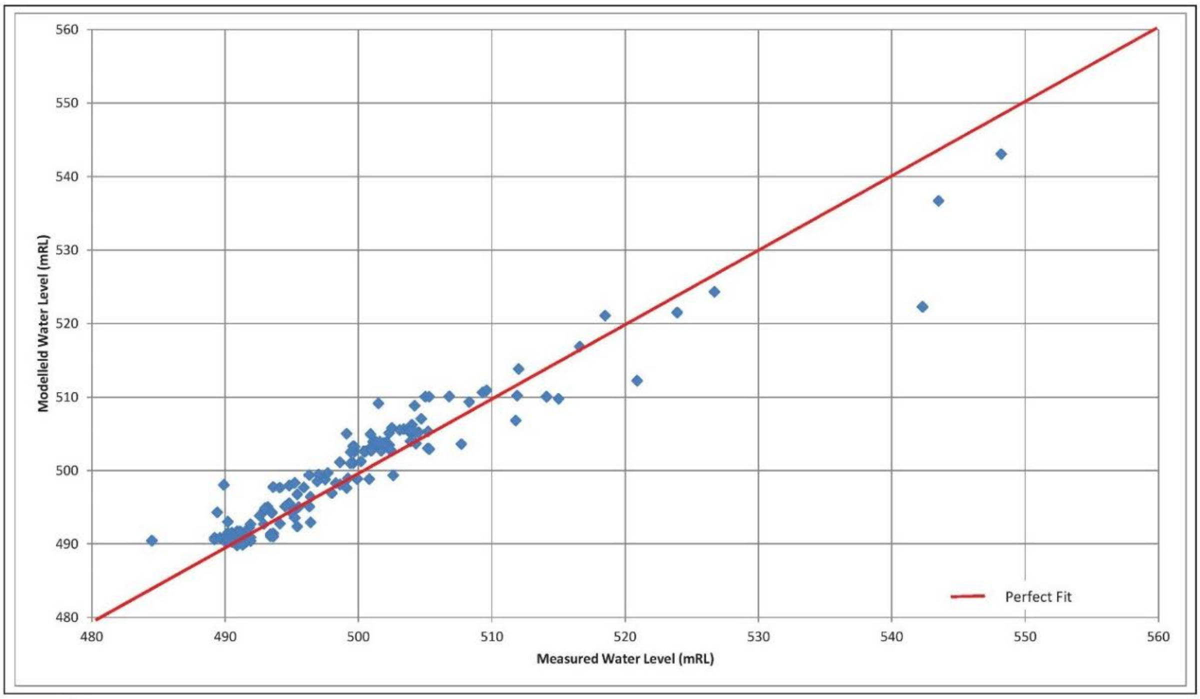
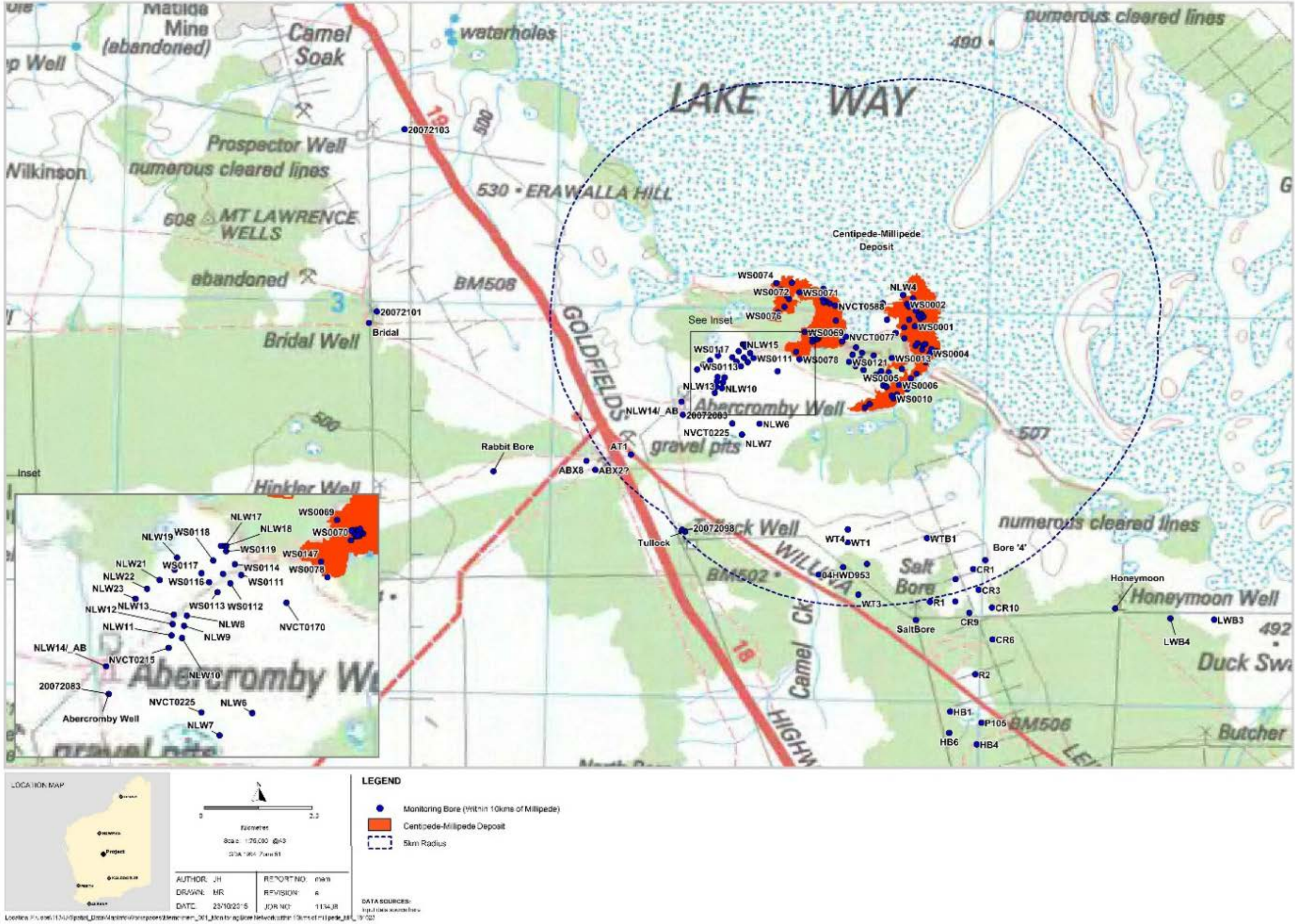


Figure 13.6: Local bores used for calibration of Millipede/Centipede hydrogeological model



Virtually all of the bores used to develop the hydrogeological model were installed in the same shallow lake deposits that host the Millipede orebody (Table 13.3)

Modelling was conducted to represent groundwater behaviour for up to 1000 years (RPS, 2015b – Appendix 10.56). The modelling included sensitivity testing to examine the effect of different input values for key aquifer properties. The model predictions include:

- At the end of mining, the 0.2 m groundwater level drawdown contour is predicted to extend 8.6 km eastwards from the mine area beneath Lake Way and 3.8 km westwards towards Abercromby Well. The 0.5 m drawdown contour is predicted to extend 4 km to the east-northeast and 3 km to the west-south-west (Figure 13.7).
- During the operational life of the mine, groundwater levels in very close proximity to the pits will drop from the pre-mining elevation (approximately 490.5 mAHD) to between 1 m and 2 m below the base of the mine voids (approximately 483 mAHD) Figure 13.8).
- After dewatering stops, groundwater levels within the mining panels will recover close to their pre-development levels after a period of 70 years following the completion of dewatering (Figure 13.9).
- The majority (90%) of recovery is predicted to occur within 60 years of the cessation of dewatering (Figure 13.9).

Table 13.13: Details of local bores used in hydrogeological modelling at Millipede/Centipede

Bore ID	Easting * MGA94_51	Northing*	Ground surface elevation, RL mAHD	Total bore depth, m	Depth to water, m	Watertable elevation, RL mAHD	Aquifer screened (eg, superficial alluvials, calcrete, palaeochannel, fractured rock, etc)**
WS0001	238323.07	7029609.8	491.68	20	1.64	490.04	silicified clays and aggregates + calcrete from surface over interbedded sands and clays
WS0002	238124.08	7030180.14	491.73	20	1.2	490.53	poorly consolidated clays and sands, silcrete from 3-5m, sand/clay below
WS0003	238087.84	7029292.66	497.3	15	0.2	497.1	transported sands at surface, silcrete with clay in void space from 5m-end of hole
WS0004	238684.35	7028925.75	491.61	20	0.43	491.18	transported sands at surface, calcrete and silcrete from 4-5m, poorly sorted sands and clays below
WS0005	238044.24	7028509.38	493.98	20	3.5	490.48	transported dune material at surface, calcretisation and silicification from 1.5-4.5, sands and clays below
WS0006	237986.96	7028094.54	494.7	20	2.21	492.49	aeolian sands at surface, calcrete from 1.5-4.5m, silty sands and clays below
WS0007	237569.63	7028439.58	494.38	18	3.9	490.48	Alluvial over calcrete
WS0008	237747.17	7028411.24	495.39	20	4.9	490.49	aeolian sands at surface, calcrete from 3-7m, silty sands and clays below
WS0009	237625.59	7028073.65	494.89	20	4.39	490.5	Interbedded sand and silcrete
WS0010	237866.65	7027750.21	491.74	20	1.04	490.7	transported clays and silts, thin silcrete unit 1-2m, sands varying to gravel and clays below
WS0011	238186.84	7027989.52	491.78	20	1.11	490.67	silty material covering, thin calcrete unit 1.5-2.3m, clay and sands below
WS0012	238348.03	7029110.64	491.95	20	1.45	490.5	silty clays covering calcrete and silcretes from 0.5-3m, clays and sands below
WS0013	237811.12	7028783.85	499.05	20	7.7	491.35	thick silts clays and sands at surface, silcrete from 9-13m, sands and clays below
WS0014	238387.82	7028390	491.8	20	1.01	490.79	clays and silts at surface, thin calcrete unit 0.5-1m, clays and sands below
WS0015	238837.51	7028980.37	491.4	20	0.97	490.43	silty sands covering silcrete from 2.5-4m, sands silts and clays below

Bore ID	Easting * MGA94_51	Northing*	Ground surface elevation, RL mAHD	Total bore depth, m	Depth to water, m	Watertable elevation, RL mAHD	Aquifer screened (eg, superficial alluvials, calcrete, palaeochannel, fractured rock, etc)**
WS0016	238708.96	7029630.31	490.93	20	0.44	490.49	clays silts and sands from surface, thin silcrete unit 10-11m, clays and sands below
WS0069	235785.06	7029409.58	493.59	20	3.1	490.49	Calcrete from surface, increasing silica to 4m, clays and sands below
WS0070	235962.87	7029168.37	491.76	17.8	1.5	490.26	clays and sands from surface, coarse gravels at 11m, sands and clays below
WS0071	235645.06	7030428.98	492.88	14.8	2	490.88	calcareous sands from surface, overlying calcrete with increasing silica to 4m, clays and sands below
WS0072	235466.23	7030669.6	492.54	15.8	1.9	490.64	calcareous sands from surface, overlying calcrete with increasing silica to 3m, clays and sands below
WS0073	235225.97	7030490.99	496.11	11.8	5.8	490.31	clays and sands from surface, thin silcrete 5-6m, clays and sands below
WS0074	235106.4	7030650.11	493.31	11.8	2.8	490.51	aeolian sands covering calcareous sands and calcrete to 3.5m, silty sands below
WS0075	235405.53	7030249.53	494.17	11.8	4	490.17	silty clays and sands from surface, calcrete and silcrete from 1.5-3.5m, silts and clays below
WS0076	235305.54	7030049.46	495.45	11.8	5	490.45	clays an sands from surface, calcretes and silcretes from 4-6.5m, clays and sands below
WS0077	235125.55	7029788.88	494.81	11.8	4.6	490.21	clays and sands from surface,cacrete from 2-5m, clays and sands below
WS0078	235681.43	7028709.13	494.13	11.8	4.6	489.53	thin clay and sand cover, calcrete 2-2.8m, poorly consolidated silcrete below
WS0089	238467.57	7029929.79	491.6	10	1	490.6	clays and silts a surface, silcrete from 1-5m, clays and sands below
WS0090	238431.99	7029910.99	491.69	10	1.1	490.59	Interbedded clays and silcrete
WS0091	238404.85	7029879.85	491.47	10	0.9	490.57	aeolian sands cover, pooly consolidated silcrete with gravel from 0.5-4m, sands and clays below
WS0092	238424.92	7029851.22	491.5	10	1.1	490.4	poorly consolidated silcretes with sands and clays
WS0093	238450.81	7029875.53	491.59	10	1	490.59	poorly consolidated silcretes with sands and clays

Bore ID	Easting * MGA94_51	Northing*	Ground surface elevation, RL mAHD	Total bore depth, m	Depth to water, m	Watertable elevation, RL mAHD	Aquifer screened (eg, superficial alluvials, calcrete, palaeochannel, fractured rock, etc)**
WS0094	238465.58	7029898.02	491.62	10.5	1	490.62	poorly consolidated silcretes with sands and clays
WS0095	238485.15	7029887.36	491.67	10	0.5	491.17	poorly consolidated silcretes with sands and clays, minor calcretisation
WS0096	238469.18	7029857.86	491.56	10	0.5	491.06	poorly consolidated silcretes with sands and clays, minor calcretisation
WS0097	238516.31	7029860.41	491.71	10	1.2	490.51	poorly consolidated silcretes with sands and clays, minor calcretisation to 8m, sands and clays below
WS0098	238442.54	7029808.72	491.48	11	1	490.48	clays and silts from from surface, silcrete 4-6m, clays and sands below
WS0099	235984.91	7029283.86	491.84	10	1.3	490.54	clay from surface, calcrete 0.5-3m, clays and sands below
WS0100	236020.59	7029241.8	491.87	10	1.2	490.67	sands and clays from surface, minor calcrete at 1m, sands and clays below
WS0101	236026.67	7029215.65	491.86	10	1.2	490.66	thin sandy clay covering silcrete and calcrete to 2.5m, clays and sands below
WS0102	236068.12	7029226.1	491.8	10	1.2	490.6	clays and gravels covering calcrete from 2-3m, sands and clays below
WS0103	236109.11	7029254.84	491.86	10	1.1	490.76	sands and clays from surface, minor calcrete at 1m, sands and clays below
WS0104	236082.5	7029266.78	491.9	10.5	1.1	490.8	clays and sand covering calcrete 0.5-3.5m, clays and sands below
WS0105	236060.11	7029281.49	491.83	10	1.1	490.73	clays and sand covering calcrete 1-3m, clays and sands below
WS0106	236026.45	7029294.64	491.86	10	1.1	490.76	clays and sand covering calcrete with increasing silica 0.5-4.5m, clays and sands below
WS0107	236071.8	7029308.12	491.87	10	1.1	490.77	clays and sand covering calcrete 0.5-3m, clays and sands below
WS0108	236051.05	7029250.67	491.87	10	1.2	490.67	clays and sand covering calcrete 0.5-2m, clays and sands below
WS0109	236018.7	7029270.92	491.83	10	1.2	490.63	clays and sand covering calcrete 0.5-2m, clays and sands below
WS0110	236001.05	7029252.46	491.88	14	1.1	490.78	clays and sand covering calcrete 0.5-2m, clays and sands below
WS0111	234621	7028714	495.3	7	4.7	490.6	thin sand cover over thick calcrete unit 0.-5m, clays and sand below
WS0112	234490	7028609	495.3	7	4.3	491	surficial calcrete, top to end of hole

Bore ID	Easting * MGA94_51	Northing*	Ground surface elevation, RL mAHD	Total bore depth, m	Depth to water, m	Watertable elevation, RL mAHD	Aquifer screened (eg, superficial alluvials, calcrete, palaeochannel, fractured rock, etc)**
WS0113	234334	7028498	495.38	4.5	1	494.38	surficial calcrete, top to end of hole
WS0114	234540	7028843	495.36	4.6	1	494.36	surficial calcrete, top to end of hole
WS0115	234398	7028722	495.44	4.6	1	494.44	surficial calcrete, top to end of hole
WS0116	234228	7028618	495.32	4.3	1	494.32	surficial calcrete, top to end of hole
WS0117	234132	7028726	495.28	4	1	494.28	surficial calcrete, top to end of hole
WS0118	234274	7028883	494.79	6	4	490.79	highly silicified dune material from just below surface
WS0119	234428	7029001	495.17	5	4.4	490.77	surficial calcrete, top to end of hole
WS0120	236976	7029040	497.23	8	6.2	491.03	aeolian sands cover, minor silicification at depth
WS0121	236822	7028663	494.78	6	4	490.78	aeolian sands at surface, highly feruginous cemtented sands to end of hole
WS0122	236901	7028851	494.89	6	4.2	490.69	aeolian sands at surface, highly feruginous cemtented sands to end of hole
WS0123	236976	7028559	495.26	5	1	494.26	surficial calcrete, top to end of hole
WS0124	237088	7028737	495.25	8	4.5	490.75	aeolian sands at surface, highly feruginous cemtented sands to end of hole
WS0125	237120	7028903	498.22	9	7.3	490.92	transported aeolian sands covering silicified calcrete
WS0126	237390	7028841	496.53	6	1	495.53	transported aeolian sands covering silicified calcrete
WS0127	237288	7028655	496.43	6	1	495.43	transported aeolian sands covering silicified calcrete
WS0127T	237287	7028654	496.45	4.5	1	495.45	transported aeolian sands covering silicified calcrete
WS0128	237162	7028462	495.09	9	4.4	490.69	transported aeolian sands covering silicified calcrete
WS0129	236049.19	7029226.28	491.87	10	1.1	490.77	compact clays covering calcrete from 0.5-3m, clays and sands below
WS0130	238446.8	7029921.37	491.56	13	1.1	490.46	thin clay cover over minor silcrete bands with clays and sands below
WS0142	236498.83	7029717.05	491.89	7	1.3	490.59	poorly consolidated clays silts and sands to end of hole

Bore ID	Easting * MGA94_51	Northing*	Ground surface elevation, RL mAHD	Total bore depth, m	Depth to water, m	Watertable elevation, RL mAHD	Aquifer screened (eg, superficial alluvials, calcrete, palaeochannel, fractured rock, etc)**
WS0143	236349.72	7030152.45	491.96	8	1.3	490.66	aeolian sands covering calcrete from 0.5-3m, clays and sands below
WS0144	235921.94	7030468	492.18	9	1.3	490.88	aeolian sands covering calcrete from 0.5-2.5m, clays and sands below
WS0145	235160	7029904.48	495.37	12	4.7	490.67	aeolian sands covering calcrete from 1-6m, clays and sands below
WS0146	236653.03	7029185.31	496.91	11	4.8	492.11	thick aeolian sands and dune material covering dense clays
WS0147	235599.19	7028896.5	493.41	13.9	2.6	490.81	thick aeolian sands and dune material covering dense clays
WS0148	238400.39	7029883.66	491.48	10	1.1	490.38	aeolian sands cover silcretes and calcretes from 1-5m, sands and clays below.

Figure 13.7: Maximum extent of groundwater drawdown – Millipede and Centipede dewatering

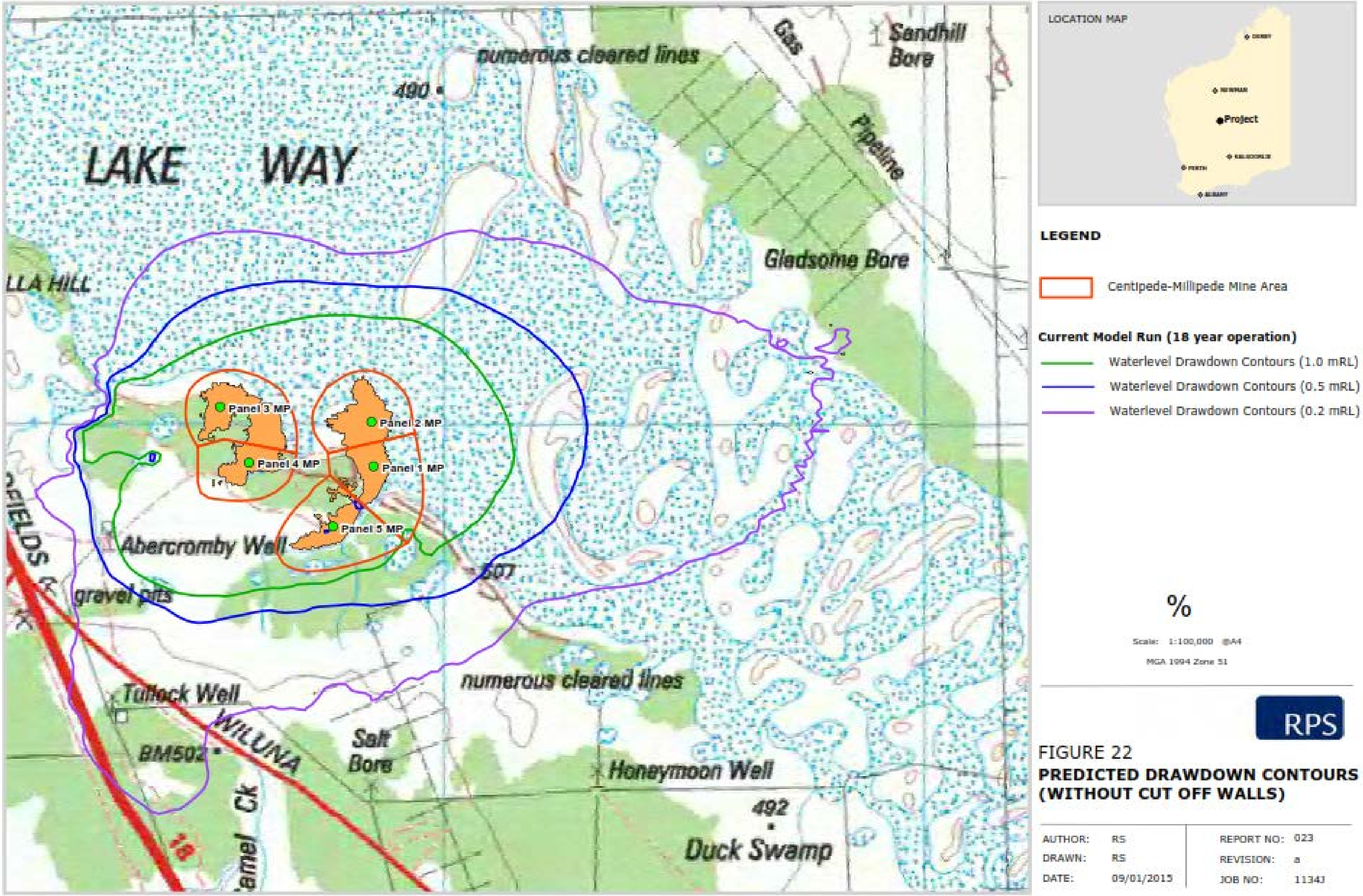


Figure 13.8: Predicted groundwater levels during mining operations – Millipede and Centipede

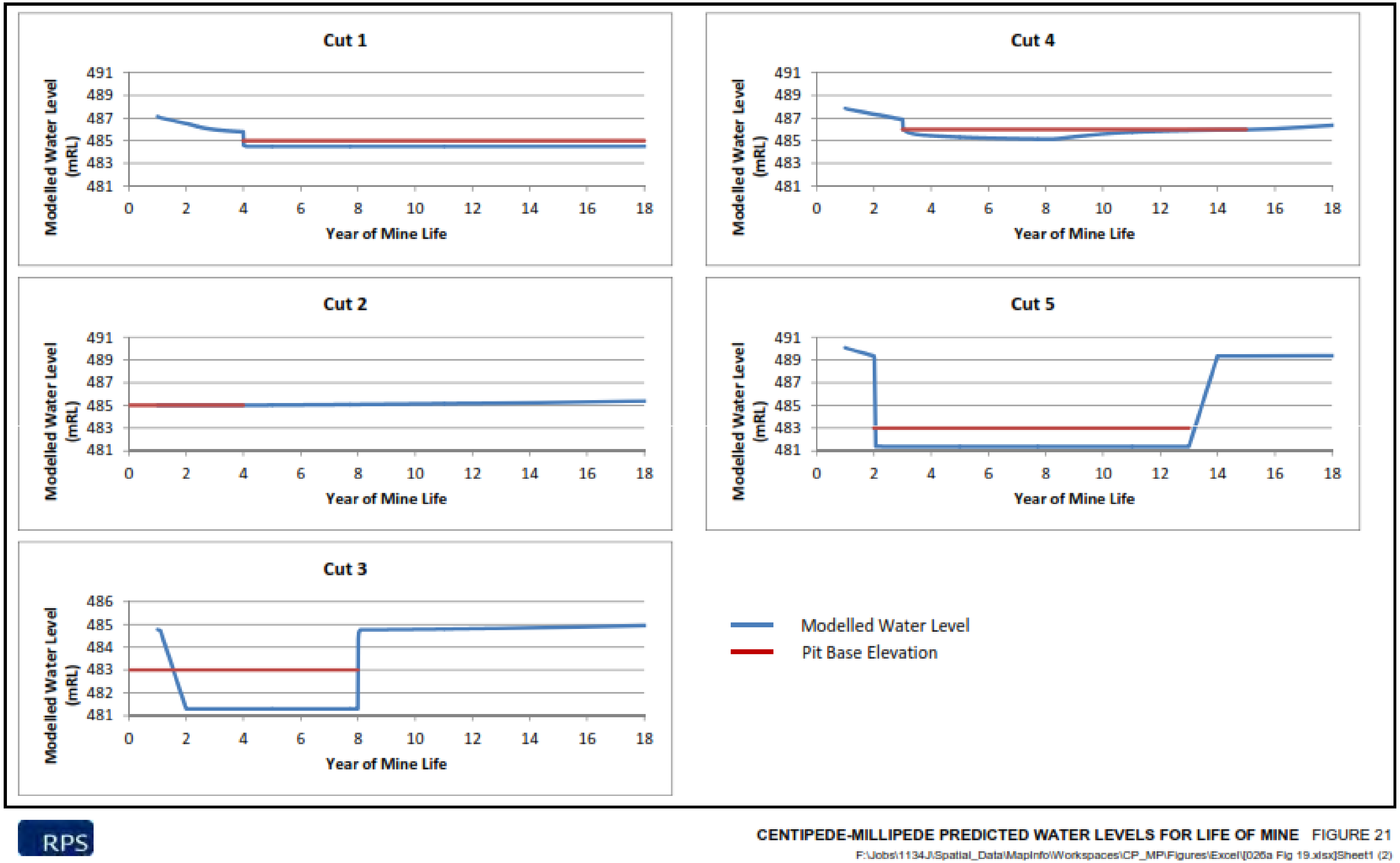
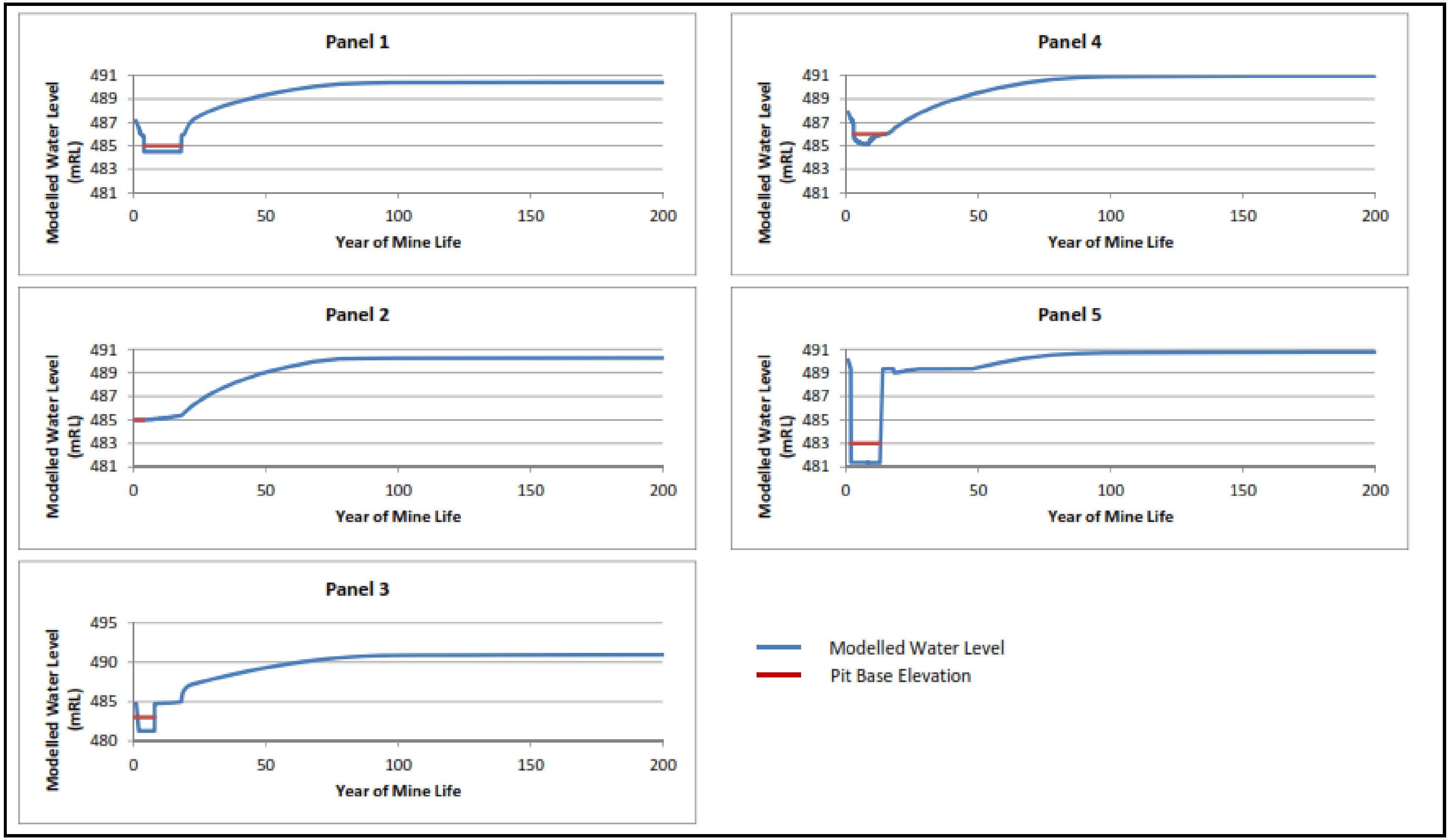


Figure 13.9: Predicted groundwater post-mining – Millipede and Centipede



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CENTIPEDE-MILLIPEDE PREDICTED WATER LEVELS POST MINING FIGURE 23
F:\Jobs\1134J\Spatial_Data\MapInfo\Workspaces\CP_MP\Figures\Excel\[026a Fig 23.xlsx]Sheet1 (2)

13.6.4 Flooding of mine pits – Lake Maitland

Unlike the Millipede deposit, the Lake Maitland deposit is located on the surface of the playa and is susceptible to flooding, especially in the event of a large flood, such as the 1-in-100 year flood. (As mentioned earlier, only localised ponding and no significant flows are likely from storms which generate less than about 60 mm of rain throughout the catchment; this corresponds approximately to a 1-in-10 year event). Flood modelling was carried out by Golder Associates in 2011 to estimate the potential flows that would occur if the mining proposal put forward by Mega Uranium were to be implemented (Golder Associates, 2011e – Appendix 10.54). That project had a somewhat larger footprint and a longer life of mine, but the hydraulic and climatic factors assessed by Golder Associates remain applicable to Toro's Lake Maitland Proposal.

Active mining at Lake Maitland would occur for approximately six years, with rehabilitation works likely to continue for at least a further year. Over a nominal 10 year operating period (construction through to closure), the risk of a 1-in-100 year flood event is about 10%. Adopting a 1-in-100 year ARI flood for design purposes therefore provides a high level of protection against inundation of the mining area.

In practice, the extent of mine areas exposed to flooding at any given time would be a subset of the total mine footprint, as the deposit would be mined progressively in about 10 panels. At any given time, parts of the deposit would be either undisturbed or rehabilitated, while others would be under active mining or backfilling.

Nonetheless, during the period of active operations flood waters need to be excluded, mainly in order to protect people and machinery. No tailings or mineralised wastes would be placed in the Lake Maitland pit voids, so the risk of tailings entrainment does not exist. In the absence of flood protection, however, there would remain some potential for erosion and sediment mobilisation.

Following the completion of mining, the mine pits would be partially backfilled and reshaped. Flood bunds would be removed to restore the lake surface to a configuration approximating the pre-mining drainage path. The rehabilitated former mine areas would again be subject to periodic, but infrequent flooding.

13.6.5 Encroachment of Mine Footprint on Drainage Lines – Lake Maitland

Lake Maitland is a much smaller lake than Lake Way and the footprint of the proposed mine would occupy a larger proportion of the natural drainage system than is the case at Lake Way. Excluding flow from the mine area by means of flood control bunds has the effect of reducing the area available for flood waters to travel down the surface of the palaeodrainage system during a large storm event. The reduced area of conveyance results in two effects:

- A temporary increase in the depth of flooding upstream of the obstruction (in this case, the mine), and
- Increased flow velocity in the remaining unobstructed drainage channel.

Hydraulic modelling of Lake Maitland has estimated that during very large floods (1-in-100 year to 1-in-500 year), the depth of flood waters near the mine could increase by up to 1.2 m to 1.3 m over and above the depth of inundation that would occur if the mine were not present (Golder Associates, 2011e – Appendix 10.54). The 'backing up' effect of bunds around the mine during a 1-in-100 to 1-in-500 year flood would result in water depths about 0.5 m greater than those that occurred following the passage of Cyclone Bobby in February 1995. The maximum increase in flood depth would occur close to the mine, but the zone affected by at least some degree of 'backwater effect' could extend up to about 2 km upstream (north and north-west) of the mine.

Flood levels would remain at their maximum depths for only a short period: typically in the order of about 12 hours. The water levels would then decline over a period of 3 to 4 days, although the time required for the flood to dissipate would depend in part upon the duration of the storm event. Some residual water would remain in shallow depressions on the lake surface for some weeks after the flood event. The length of time the pools of water would remain would depend upon the depth of the topographic depressions and the evaporation rate (Golder Associates, 2011e – Appendix 10.54).

The natural flow velocities that would be experienced at Lake Maitland during a large flood event, but in the absence of an obstruction such as a flood control bund, would typically be up to about 1 m/s, with average velocities of around 0.6 m/s. These flow rates have the potential to cause erosion and sediment mobilisation in sandy or loamy materials, but would be unlikely to erode silty clays, gravel, cobbles or hardpans.

The predicted flow velocities during a large (1-in-100 year) flood event where the flow conveyance is reduced could reach up to around 1.5 m/s, especially towards the southern end of the mine site. The erosive power of such flows would be sufficient to erode fine gravels and possibly some cobbles, but would be unlikely to affect coarse gravels or hardpan. The implications of a very large flood occurring during the active life of the mine are:

- Some erosion of the lake surface would be likely; and
- Flood protection bunds would need to include some armouring to protect them from erosion.

13.6.6 Pit Dewatering – Lake Maitland

The potential impacts of mine dewatering have been addressed in the sections of the PER that describe the environmental values (subterranean fauna: Section 12, groundwater dependent vegetation: Section 9) that could be impacted. The predicted drawdown magnitudes and extents at Lake Maitland were initially estimated on the basis of the 13-year mine plan proposed by the previous tenement owner. The mining duration proposed by Toro at Lake Maitland is approximately six years (not including construction, closure and rehabilitation) and both the proposed depth of mining and extent of mining are less than was assumed in hydrogeological modelling. Toro has adopted the earlier modelling (Golder Associates, 2011c) as a conservative basis upon which to assess possible environmental impacts of groundwater abstraction for the dewatering of the Lake Maitland pit.

The maximum depth of groundwater drawdown in the superficial aquifer in close proximity to the mine pit was predicted to be approximately 3.5 m. Once mine dewatering stops, the model predicts that groundwater levels would recover to approximately the pre-mining levels within 10 to 20 years. Fifty percent of the recovery is expected to occur within 2 to 3 years of completion of dewatering (Golder Associates, 2011c). Given that the proposed duration of Toro's mining activities at Lake Maitland is now approximately six years, the likelihood of significant, persistent adverse impacts on groundwater reliant biota is considered low.

13.7 Impact Management

Toro's proposed strategies for managing impacts of mine dewatering and water abstraction and mine water reinjection on subterranean fauna are described in Section 12. Management of the potential impacts of these activities on groundwater dependent vegetation is described in Section 9. Additional information on the potential for long-term migration of contamination from the Millipede in-pit tailings storage facility is provided in Section 16.

Toro has applied the mitigation hierarchy in developing its strategies for protecting inland waters. A summary of control actions is provided in Table 13.14.

Table 13.14: Hierarchy of mitigation actions – application to the protection of inland waters

Potential Impact	Mitigation Approach	Details
Discharge of sediment-laden water during construction: water quality impacts	Avoid	Bulk earthworks would be scheduled to avoid the peak summer wet season (January to March), thus reducing the likelihood of significant runoff events during construction.
	Reduce	Clearing would be undertaken progressively and disturbance would be kept to the minimum required for safe and efficient implementation of the Proposal. Best practice erosion and sediment control practices would be adopted during construction and operations.
Discharge of saline or sediment-laden water from pit dewatering during operations: surface water quality impacts	Avoid	Water from pit dewatering would be used in the ore treatment circuit and would not be discharged during routine operations. Some mine dewatering water may also be used in dust suppression applications if it was of suitable quality. If more water was generated from pit dewatering than could be used in the process plant, one or a combination of the following water management strategies would be implemented: dispose of surplus water in evaporation ponds; reinject water to the aquifer from which it was abstracted; modify the mine schedule to reduce need for dewatering.
Discharge of saline or contaminated water as a result of overtopping of the TSF, evaporation ponds or other water storages: surface water quality impacts.	Avoid	During the operating phase of the Proposal, all water storages would be designed, constructed and operated to contain at least the 1-in-100 year critical storm event. An appropriate freeboard would also be provided to ensure that water would not accidentally be released to the environment.
Altered hydrology -- obstruction of flow paths: risk of impacts to riparian systems and/or vegetation communities.	Reduce/minimise	It is not possible to completely avoid disruption to existing flow paths, as mine pits and other necessary infrastructure cannot be relocated to entirely avoid drainage features. Backwater effects would be minimised by adopting a mine plan that allowed bypassing of flows around the mine pits, rather than damming of drainage lines. The design of flood protection structures would seek to balance the need for an appropriate level of flood protection and the impacts of a large engineered bund on natural flow systems. The mine haul road would constructed be with appropriately sized and spaced culverts to maintain, to the extent practicable, pre-mining surface flows.
	Rectify/restore	At completion of mining, flood protection bunds around former pits and other infrastructure would be removed, and the surface would be recontoured to restore surface flow paths.
Mine dewatering: groundwater drawdown reduces habitat available for subterranean fauna or other water dependent ecosystems	Reduce	Mining progressively in ‘panels’ would reduce the volume of pit required to be dewatered at any given time. Toro also proposes to install low permeability perimeter barriers around the mine pits to reduce water inflows to the pit (and therefore the amount of dewatering required). Field-scale trials have demonstrated that the use of perimeter barriers can reduce water influx by between 25% and 80%.

Potential Impact	Mitigation Approach	Details
Water abstraction from borefields: groundwater drawdown reduces habitat available for subterranean fauna or other water dependent ecosystems	Reduce	The main source of water for ore processing and other non-potable operational purposes would be saline water from pit dewatering. Toro has adopted an ore processing method that allows the use of very saline water, thus substantially reducing the need to access fresher water in calcrete and alluvial systems favoured by subterranean fauna.
	Reduce	The borefields proposed at West Creek and north of Lake Maitland would involve a series of bores distributed to allow adjustments in the pattern of water abstraction if required to limit groundwater drawdowns. By securing two 'make up' water sources, Toro can ensure that the amount of water abstracted does not exceed the sustainable aquifer yield at either location.
Water abstraction from borefields: reduction in amount of water available to existing water users	Rectify/restore	There is some possibility that abstraction of water from the Lake Maitland borefield may reduce the amount of water available at some existing shallow bores on the Barwidgee pastoral station (of which Toro is the tenement holder). If necessary, Toro would supplement water available for cattle owned by the pastoral station sublessee to ensure that livestock wellbeing is not compromised.
Flooding of mine pits during operational phase results in entrainment of stockpiled materials and/or tailings solids/supernatant: risk of surface water contamination	Reduce	Toro has committed to the establishment of flood control protection to prevent incursion of surface waters to operational areas throughout the active life of the Project.
Flooding of mine pits during operational phase: risk to worker safety		
Flooding of former mine areas near Millipede results in entrainment of tailings solids: risk of surface water contamination	Reduce	In pit tailings storages would be progressively rehabilitated. The tailings would be covered with a substantial engineered capping layer. No tailings would be placed above the natural ground surface, thereby reducing exposure to erosive forces and maintaining the generally flat terrain that accounts for slow surface water flow velocities in the pre-mining landscape.
In-pit storage of tailings: risk of groundwater contamination	Reduce	It is not possible to entirely eliminate the production of tailings. The risk of groundwater contamination will be substantially reduced by the placement of tailings within an engineered cell, equipped with a basal liner and a capping layer. Operational practices would be implemented to maximise long term tailings density. This would reduce the tailings permeability and further reduce the likelihood of significant contaminant release.

Potential Impact	Mitigation Approach	Details
Upward movement of soluble tailings constituents: risk of contamination of lake sediments post-closure	Reduce	The cover system proposed for the in-pit tailings storage facilities has been specifically designed to limit the potential capillary rise of soluble tailings constituents.
Reinjection of water from mine dewatering: risk of brine intrusion into calcrete aquifers, reducing subterranean habitat quality	Reduce	The main source of water for ore processing and other non-potable operational purposes would be saline water from pit dewatering. Toro has adopted an ore processing method that allows the use of very saline water, thus substantially reducing the need to rely on re-injection systems to dispose of surplus water.
Reinjection of water from mine dewatering: risk of groundwater mounding, affecting playa vegetation		
Storage and use of hypersaline water: risk of soil or surface water contamination or vegetation damage as result of spillage, seepage or loss of containment of saline water	Reduce	Notwithstanding the generally saline condition of local soils and groundwater, Toro would provide low permeability liners for any saline water storages to limit the risk of seepage. Pipelines would be installed within a bund and equipped with leak detection systems to minimise damage in the event of a pipeline breach.

13.7.1 In-pit Tailings Storage

As described in Section 6.12.1, Toro proposes to permanently store tailings from the processing of Millipede and Lake Maitland ore in an in-pit TSF constructed within the mine void at the Millipede deposit. The tailings containment system proposed at Millipede is the same as previously assessed at Centipede (EPA Assessment 1819 and EPBC 2009/5174). The design of the TSF, at closure and post-closure, includes a low permeability clay liner in the base, water barriers around the sides of the TSF and a multi layer cover. This measure provides additional control on possible movement of soluble tailings and constituents, in addition to the seepage controls provided by the:

- Inherently low permeability of the tailings mass ($1x10^{-8}$ m/s (Knight Piésold, 2013b)); and
- Low hydraulic gradients and high evaporative demand in the Project area.

The TSF would be designed, constructed and operated in accordance with DMP requirements and with applicable recommendations contained in the ANCOLD guidelines (ANCOLD, 2001; 2012), including those relating to post-closure monitoring and maintenance. At closure, the Millipede TSF would be covered with a multi-layer cover system incorporating the same features as proposed for the Centipede in-pit tailings storage. Details of the closure cover system are presented in Section 16.4.

Normally, flood protection bunds on operating mines in Western Australia are required to protect against the ‘critical’ 1-in-100 year storm event (the event that delivers the most water), plus providing an allowance for 'freeboard' (an allowance to ensure that settlement of the bund and wave and wind action will not result in overtopping). At Millipede, the estimated 1-in-100 year flood depth would be in the order of 1.5 m. A freeboard of at least 1 m is generally recommended to protect significant assets.

The in-pit tailings storage at Millipede would incorporate flood protection measures already required for the Centipede in-pit storage. Under the existing federal approval for tailings storage at Centipede, Toro is required to provide perimeter bunds and associated drainage to ensure that there would be no incursion of flood waters into the mine pits, even in the event of the estimated PMF event. The same engineering requirements would apply to the Millipede tailings storage.

At Project completion, the mine pits at Millipede would be fully backfilled and capped, so there would no longer be a need to retain flood diversion bunds. However, the capping system would need to be designed to withstand the erosional forces of running water and/or wave action following significant storm events, so as to ensure that the cover layer would remain intact. Traditional Owners from the Wiluna area have told Toro that it is important to them that the lake surface should be rehabilitated so that it returns to a condition similar to the pre-mining topography. Toro has taken this preference into account in designing post-closure landforms at Millipede. More information on mine rehabilitation and closure is provided in Section 16.

To date, Toro's modelling of potential seepage of tailings constituents in the event of a catastrophic loss of containment from in-pit storage facilities has involved extremely conservative assumptions (no dispersion from surrounding groundwater, release from a constant source over hundreds of years, no influence of reducing conditions in surrounding sediment, no influence of carnotite solubility controls). Further geochemical characterisation and modelling work is proposed to gain an even better understanding of the likely long-term behaviour of tailings stored at the Millipede/Centipede in-pit facilities. The results of this work will be used to further inform groundwater monitoring strategies and associated contingency plans.

13.7.2 Operational Water Requirements

The life of Project (including its extension) requirements for fresh to brackish water (all operational applications) and for hypersaline water used in mineral processing are summarised in Table 13.5 and Figure 13.14. Table 13.5 shows the amount of water required for processing applications (including steam production) and for potable/amenities purposes is effectively constant. However the amount of water required for controlling dust varies, depending upon the area (mainly road surfaces) over which dust control is required. The amount of water required for dust suppression shown in Table 13.5 allows for the use of proprietary additives in dust suppressant fluids which significantly reduces water requirements. Toro will consult with the DMP about the acceptability of using higher salinity water on haul roads, given the relatively high salinity background environment in areas near Lake Way and Lake Maitland. The use of high salinity water may require special application techniques, such as the use of 'dribble bars' (rather than sprays) to limit the risk of overspray from water trucks.

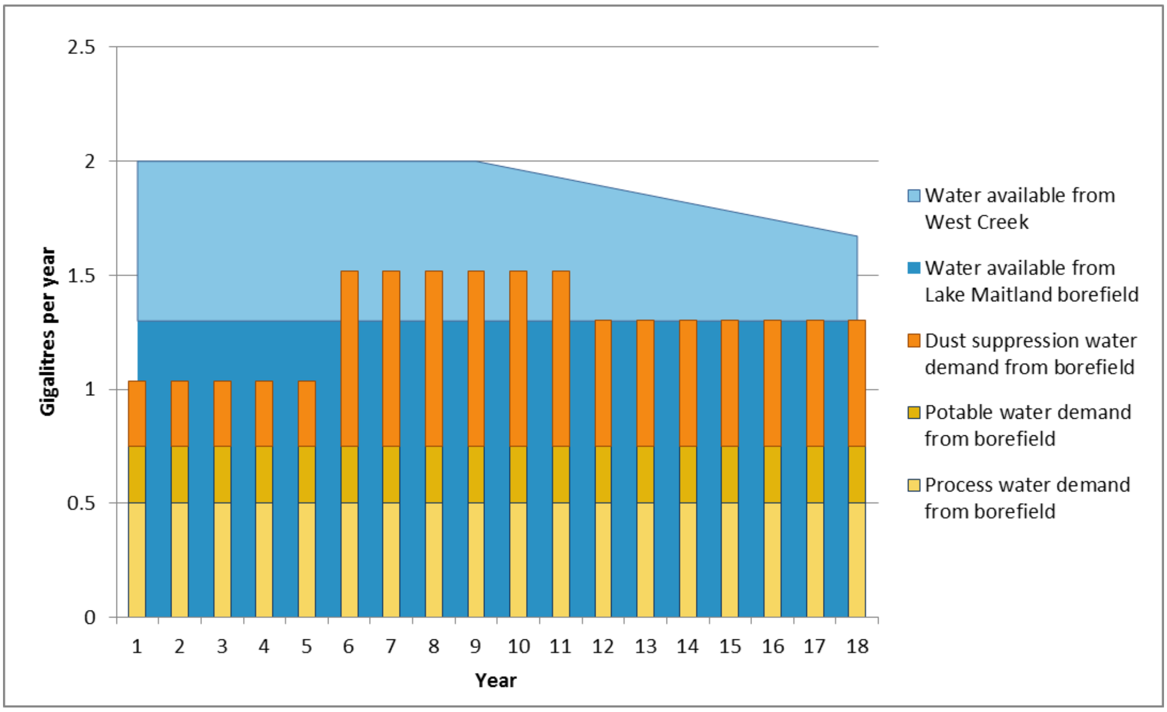
Table 13.15: Year-by-year water demand

Year	Potable water, GLpa	Process water (fresh to brackish), GLpa	Process water (saline), GLpa	Dust suppression water (<10,000 TDS), GLpa
1	0.05	0.25	1.26	0.3
2	0.05	0.25	1.26	0.3
3	0.05	0.25	1.26	0.3
4	0.05	0.25	1.26	0.3

Year	Potable water, GLpa	Process water (fresh to brackish), GLpa	Process water (saline), GLpa	Dust suppression water (<10,000 TDS), GLpa
5	0.05	0.25	1.26	0.3
6	0.05	0.25	1.26	0.81
7	0.05	0.25	1.26	0.81
8	0.05	0.25	1.26	0.81
9	0.05	0.25	1.26	0.81
10	0.05	0.25	1.26	0.81
11	0.05	0.25	1.26	0.81
12	0.05	0.25	1.26	0.58
13	0.05	0.25	1.26	0.58
14	0.05	0.25	1.26	0.58
15	0.05	0.25	1.26	0.58
16	0.05	0.25	1.26	0.58
17	0.05	0.25	1.26	0.58
18	0.05	0.25	1.26	0.58

In most years all of the fresh to brackish water required could be supplied by the Lake Maitland borefield, which has been assessed as being able to supply 1.3 GLpa over at least a 20 year period (RPS, 2014b, Appendix 10.55). However, during the period of active mining at Lake Maitland, there is a higher water requirement associated with a higher dust control demand. This is illustrated in Figure 13.14. During this period, a supplementary water source – the West Creek borefield – would be required to provide an additional 0.3 GLpa of fresh to brackish water. The West Creek borefield has previously been operated by other users at an abstraction rate of approximately 0.7 GLpa. However, Toro's recent review of sustainable groundwater yields from the proposed West Creek borefield (RPS, 2014a – Appendix 10.31) has indicated the desirability of diversifying the Project water supply and making use of water from mine dewatering to the extent practicable, as well as from Lake Maitland. This would allow more flexibility in borefield operations and enable Toro to respond adaptively to ongoing water monitoring results at each borefield.

Figure 13.10: Borefield water supply and demand



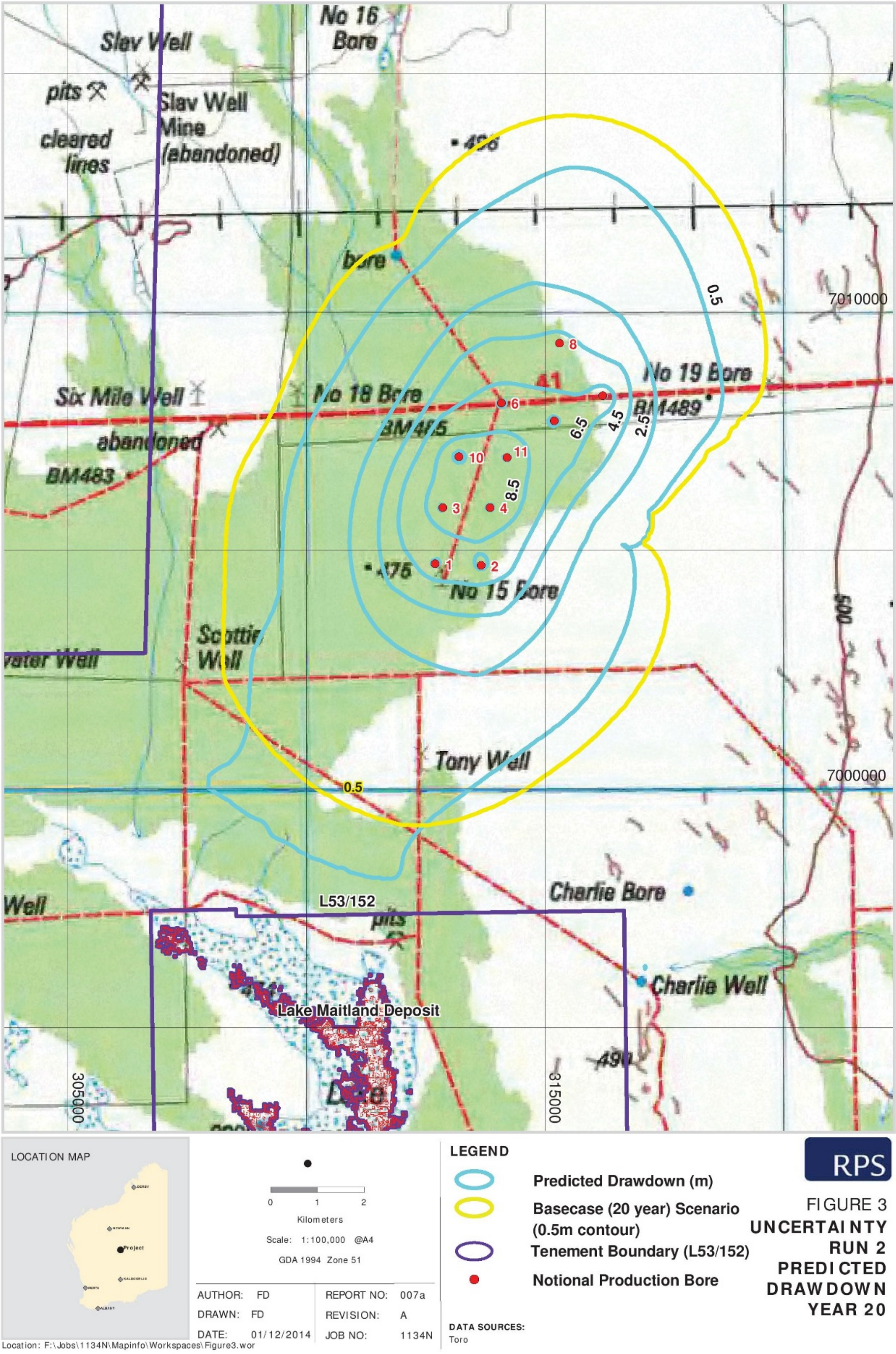
The amounts shown in Figure 13.10 are the amounts that would need to be drawn from a borefield, assuming an average groundwater salinity of 3000 mg/L. The quantities shown in Figure 13.10 are not exactly the same as those shown in Table 13.15 because Figure 13.10 makes provision for the fact that water from the borefields would have to be treated by means of reverse osmosis to make it suitable for some applications. For example, water used for drinking would need to be desalinated to bring the total salt content down to less than 600 mg/L total dissolved solids to ensure that it is palatable. The amount of water that would have to be abstracted to produce 0.05 GLpa of potable water would be in the order of 0.25 GLpa, assuming a conservative recovery ratio of 20%[1]. The quantities shown in Figure 13.10 also assume that only water having a salinity equal to or less than 10,000 mg/L can be used for dust suppression.

13.7.3 Water Abstraction – Lake Maitland Borefield

Hydrogeological studies and modelling for a proposed borefield to the north of Lake Maitland have demonstrated that the alluvial aquifer can readily sustain water abstraction of 3600 kL/day (1.3 GL/a) for at least 20 years (RPS, 2014b – Appendix 10.55). After 20 years of water abstraction at this rate, a maximum water drawdown of around 6.5 m is predicted at the centre of the borefield, corresponding to approximately 21% of the saturated aquifer thickness at that location. The estimated extent of significant (0.5 m) groundwater drawdown after 20 years of operation is a maximum distance of 8 km to the north, 7.5 km to the south and 4.5 km to the east and west of the proposed borefield (Figure 13.11).

[1] That is, it has been assumed that for every litre of brackish water treated, the reverse osmosis system delivers 0.2 L of drinking quality water. For process water (which has less stringent quality requirements) a recovery ratio of 50% has been assumed, which means that for every litre of water abstracted from the borefield, 0.5 L of useable fresh water would be delivered by the reverse osmosis system.

Figure 13.11: Predicted groundwater drawdown – Lake Maitland borefield at 20 years



If Toro were to continuously operate the borefield at an abstraction rate of 1.3 GL/a, there is potential for the groundwater drawdown cone to intersect parts of the aquifer accessed by existing pastoral bores on the Wonganoo and Barwidgee Stations. Toro is the tenement holder of the Barwidgee Station. If operation of the Lake Maitland borefield interferes with water supply to the Wonganoo Station, Toro will make good the Wonganoo water supply by means of water troughs and off-take lines from the borefield.

Following cessation of water abstraction from the Lake Maitland borefield, the aquifer is expected to fully recover. Conservative model predictions (assuming no significant recharge events following mine closure) predict 75% aquifer recovery within approximately 30 years (RPS Aquaterra, 2011b).

13.7.4 Flood Control – Lake Maitland

Changes to surface hydrology at Lake Maitland chiefly arise as a result of the obstruction to surface flows that result from the construction of flood control bunds around the mine. During very large flood events, the reduced conveyance area could result in backwater effects and increased erosion of the lake surface. The duration of flooding is not likely to change significantly. The likelihood of such impacts occurring is relatively low: there is only about a 10% chance that a 1-in-100 year flood would occur during the active life of the mine. If such an event were to occur, it might happen at a time when the flood bunding is not at its maximum extent.

It is not an option to omit flood control bunds around the mine. However, during its detailed mine planning and design, Toro will seek to minimise the potential impacts of flood control infrastructure through adjustments to the mine panel sequencing. In the event that a major flood would cause significant erosion at or downstream of the mine, the affected areas would be rehabilitated as part of mine closure works. All flood control channels and bunds would be decommissioned and rehabilitated at mine closure and the surface would be recontoured to approximate the pre-mining drainage system.

13.7.5 Pit Dewatering – Millipede

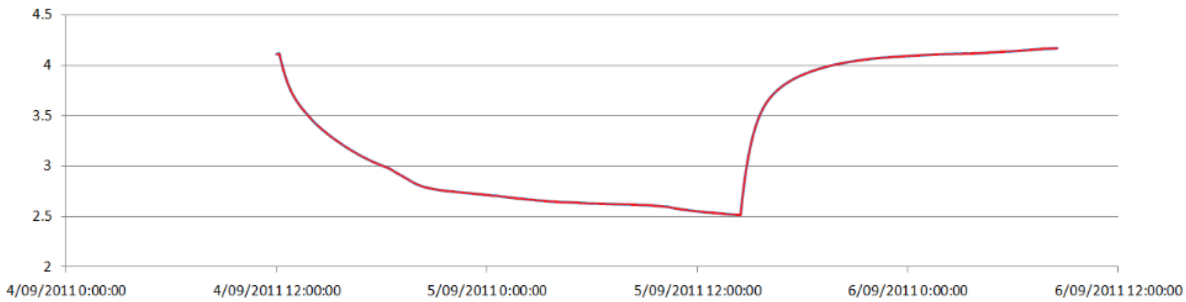
Toro's planned mining approach, which involves mining in panels, with progressive backfilling and rehabilitation of mined-out voids, will help to limit the impact of mine dewatering: the smaller the open area of mine pit, the less dewatering is required, and the lower the potential impacts of dewatering.

The key engineering design element for managing the potential effects of groundwater drawdown from dewatering of the Millipede mine pit is the installation of low permeability perimeter barriers outside the Millipede pit shell. The use of perimeter barriers will both reduce the amount of water that flows into the pit and reduce the magnitude and extent of changes to groundwater levels outside the pit. Toro has conducted field-scale trials to test the likely effectiveness of a range of barrier types. The trial pit used in the tests measured approximately 40 m x 40 m. The perimeter barriers were excavated to a nominal depth of 4 m (Figure 13.12).

Figure 13.12: Field trial of perimeters showing trench (left) and dewatered pit (right)

Groundwater drawdown was measured as the pit was dewatered and the rate of water recovery was observed when dewatering stopped (Figure 13.13). This information was used to estimate the efficiency of the water barriers. Three separate trial installations were assessed. The estimated reduction in water influx to the pits ranged from 20% (for an HDPE barrier) to nearly 80% (for a compacted clay barrier). Toro is confident that the use of perimeters can reduce water inflow to the mine pits by at least 30%.

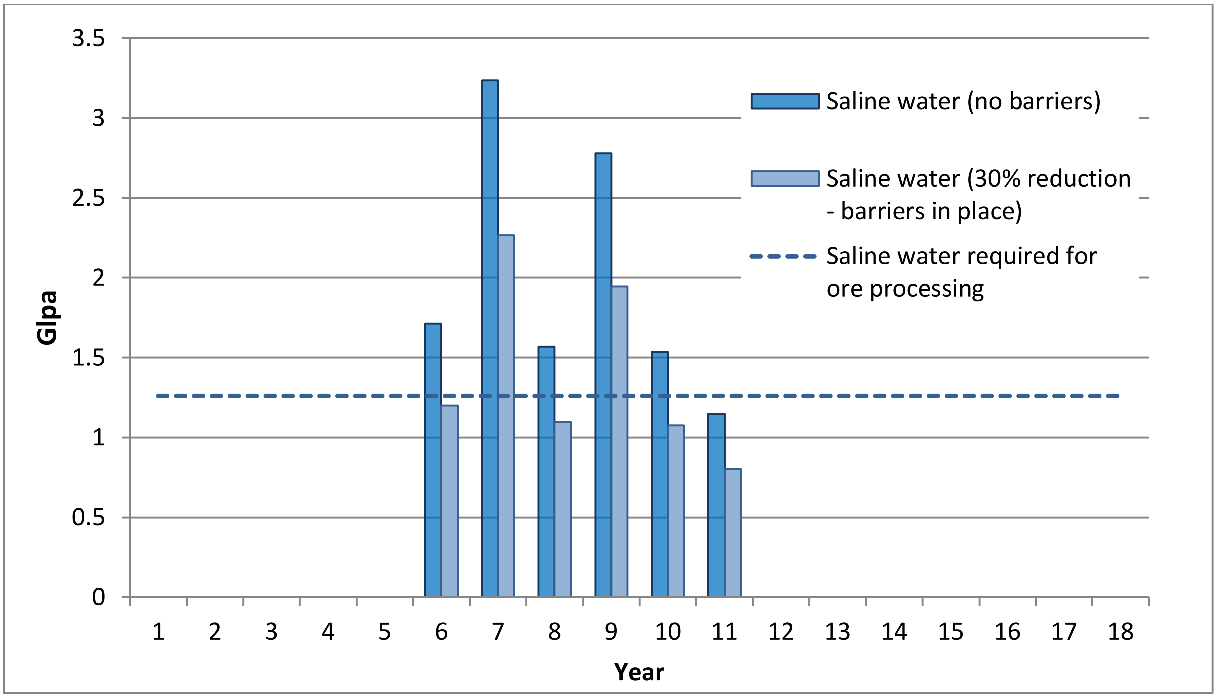
Figure 13.13: Barrier trial drawdown curve



13.7.6 Pit Dewatering – Lake Maitland

Toro's key strategy for managing the potential impacts of mine pit dewatering at Lake Maitland is to seek to reduce water influx to the pits through the use of engineered, low permeability barriers. This would have the dual benefits of reducing the magnitude and extent of groundwater drawdown (thereby reducing impacts on subterranean fauna habitat) and simplifying the management of intercepted water. Field-scale trials conducted at Lake Maitland have demonstrated the feasibility of using engineered barriers to significantly reduce water influx (Golder Associates, 2011b). Early trials of perimeter barriers realised reductions in water flow ranging from 26% to 30%. In the absence of low permeability barriers, the estimated volume of mine dewatering at Lake Maitland ranges from approximately 1.1 GL/a to 2.8 GL/a (Golder Associates, 2015 – Appendix 10.9). With barriers in place and assuming a 30% reduction in inflow as a result of constructing perimeter barriers, the amount of dewatering required at Lake Maitland would range from 0.8 GL/a to 2.27 GL/a (Figure 13.14).

Figure 13.14: Estimated pit dewatering requirements – Lake Maitland



Data source: Golder Associates (2015)

Up to approximately 1 GL/a of hypersaline water can be used in ore processing (Figure 13.14), so in some years there would be no requirement to manage surplus water from mine dewatering. Water recovered from pit dewatering would be pumped to the ore processing plant in a bunded, above ground pipeline installed alongside the haul road running between Lake Maitland and the processing plant.

There would be periods during which the amount of water generated through mine dewatering at Lake Maitland exceeds operational water requirements. Toro proposes to manage surplus water through a combination of reinjection of water back into the aquifer from which it came and evaporation of water from lined basins. Field-scale trials and modelling have been carried out to evaluate the amount of water that could be reinjected to the shallow aquifer at Lake Maitland without causing excessive mounding of groundwater. Those studies have estimated that approximately 1 GL/a of surplus water could be reinjected over a period up to 15 years using a nominal array of 24 reinjection bores spaced 500 m apart (Pennington Scott, 2015a; 2015b – Appendix 10.30). Further modelling was undertaken by Pennington Scott to assess the impacts of a borefield and reinjection program that lasted six years. This modelling showed that the impacts due to groundwater mounding were significantly reduced with the shorter life of the Proposal and that to protect subterranean fauna populations there were numerous borefield configurations that the Proposal could adopt (Pennington Scott, 2015b – Appendix 10.30). The modelling has confirmed that the concept of reinjection will work in the region and further engineering work will take place as part of the Definitive Feasibility Study to design a borefield with the lowest practicable impacts on local subterranean fauna populations.

A limited amount of water (in the order of 0.15 GL/a) could be disposed of through evaporation. Although the hot, dry conditions in the Lake Maitland area favour evaporation, very saline water does not evaporate as quickly as freshwater. The 8 ha evaporation basin included in the design of the Proposal would not be sufficient to accommodate all surplus mine water in every year. The evaporation pond would be managed mainly as a contingency, in case maintenance or repairs are required on the reinjection system or higher than expected mine dewatering results in more water than can be accepted by the reinjection system.

In the event that groundwater inflow to the pits is larger than predicted by hydrogeological modelling to date, or the efficiency of the reinjection system is lower than expected, then Toro would adjust the mine plan to reduce the volume of pit requiring dewatering.

13.7.7 Pit Dewatering – Cumulative Impact Assessment

Across the Millipede and Lake Maitland deposits, dewatering is required to allow mining. Due to the locations of each deposit, the groundwater is hypersaline with TDS values of over 100,000 mg/L being normal. Due to its low quality, the abstraction of groundwater associated with the Proposal would have no impacts on other users within the region. There are no other projects currently located on the lake playas, so there are no cumulative impacts associated with mine dewatering.

At the Lake Maitland borefield, brackish water would be abstracted as the primary source of water for the Proposal. A search of groundwater licences in the region was undertaken by RPS who found that there were no 5C licences within the region. The only users of water within the immediate vicinity of the borefield are the local pastoral stations at Barwidgee and Wonganoo. These bores are used to supply water to cattle and are unmetered. These bores generally only pump during certain periods of the year and yield limited volumes. The cumulative impacts of the operation on the borefield and the station bores are expected to be insignificant.

13.8 Commitments

- Toro would not abstract more than 0.7 GL/a from the proposed West Creek borefield in accordance with EPA Assessment 1819 and EPBC 2009/5174. The borefield would be designed and operated to maintain at least 60% saturation in the aquifer from which water is abstracted. Groundwater drawdowns would be monitored regularly and, if required, water abstraction would be modified to ensure protection of water-dependent biota.
- Toro would not abstract more than 1.3 GL/a from the proposed Lake Maitland borefield. If water abstraction interferes with the quality or quantity of groundwater available to existing groundwater users, Toro would make good the water supply under a water sharing agreement with the affected parties.
- Further work would be implemented to optimise the design and location of groundwater reinjection systems at Lake Maitland. The reinjection system would be designed and operated to prevent excessive mounding of groundwater and to prevent salt water intrusion that could affect subterranean fauna communities of the Barwidgee calcrete.
- Pipelines conveying saline water from mine dewatering would be installed within bunds to limit the risk of uncontrolled release of saline water in the event of a pipeline failure.
- The haul road between Lake Maitland and the Millipede/Centipede processing area would be constructed as a floodway with appropriately sized and spaced culverts to maintain surface flows where the road alignment crosses drainage lines.
- Best practice erosion and sediment control measures would be implemented during construction and throughout the life of the Proposal.
- Low permeability barriers would be installed to limit water influx to the Millipede and Lake Maitland mine pits consistent with EPA Assessment 1819 and EPBC 2009/5174. Water from mine dewatering would be used preferentially to satisfy production requirements. Surplus water from mine dewatering at Lake Maitland would be reinjected or evaporated in lined basins. The reinjection system would be designed and operated in accordance with relevant principles set out in DoW's *Operational policy 1.01 — Managed aquifer recharge in Western Australia* (2011).
- Toro will undertake further geochemical modelling of the effects of uranium in local groundwaters as the result of seepage from the TSF. This modelling will be done prior to the

submission of the Project's Mining Proposal and the results of the modelling will be included in that proposal and the Project's Mine Closure and Rehabilitation Plan.

- All mine pits would be bunded to a level that excludes flow from at least the 1-in-100 year flood event. Flood control bunds would be engineered to accommodate erosional forces. At Project completion, flood control channels and bunds would be decommissioned and removed. The land surface would be recontoured and rehabilitated to approximate the pre-mining drainage system.

13.9 Outcome

Implementation of the proposed water management strategies is expected to:

- Maintain aquifer water levels required for the protection of water-dependent biota;
- Eliminate the need for surface discharge of mine dewatering water during routine operations;
- Make best use of saline groundwater, so as to minimise the need for consumption of fresh to brackish groundwater; and
- Maintain groundwater quality surrounding the in-pit tailings storages both during mining operations and post-closure.

As discussed in Section 9 and Section 12, the Proposal can be implemented with no long-term or residual impacts on flora, vegetation and subterranean fauna. This is consistent with the objectives of this key environmental factor.

14 HUMAN HEALTH

14.1 Objective

To ensure that human health is not adversely affected.

14.2 Relevant Legislation and Policy

The main focus for human health is radiation. The following Western Australian Acts and regulations provide for radiation protection:

- *Radiation Safety Act 1975*;
- *Radiation Safety (General) Regulations 1983*;
- *Radiation Safety (Transport of Radioactive Substances) Regulations 2002*;
- *Mines, Safety and Inspection Act 1994*; and
- *Mines, Safety and Inspection Regulations 1995*.

In general, the approach to radiation protection in Australia is based on internationally recognised systems and standards. The ICRP, as the primary international body for radiation protection, regularly publishes guidelines in the form of formal recommendations.

ARPANSA, as the national authority in Australia for radiation protection, reviews International Atomic Energy Agency safety standards for their use in Australia. ARPANSA's primary functions are the dissemination of information and development of world's best practice for radiological protection in Australia. The As Low As Reasonably Achievable (ALARA) principle is the basis of radiation management.

ARPANSA has published a wide range of documents relevant to radiation protection in uranium mining. These include:

- *The Code of Practice and Safety Guide for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing 2005*; and
- *The Code of Practice for the Safe Transport of Radioactive Material 2014*.

These Codes incorporate recommendations of the ICRP and are referenced in various legislative instruments by Australian jurisdictions.

The primary Guidance Documents in Western Australia are the Managing Naturally Occurring Radioactive Material (NORM) Guidelines which describe in detail radiation control systems and processes.

14.3 Proponent Studies and Investigations – Millipede

Where mining is proposed at Millipede and also at Centipede and Lake Way, radiation assessments have been carried out over a period of more than 30 years by a number of different companies. The Millipede deposit is immediately adjacent to the Centipede deposit. Work undertaken for the assessment process for the Centipede deposit is directly applicable to Millipede. Assessments have been both investigative (for impact assessments) and routine (radiation management during exploration or pre-mining activities). The information presented in this section draws on historic background radiation monitoring and investigations up until 2008, and chiefly draws on data collected since then by Toro specifically for the purpose of assessing the potential impacts of the Wiluna Uranium Project, including its Extension.

Radiation studies undertaken include:

- Investigative studies for a 1981 Environmental Impact Statement (EIS) for uranium mining at Centipede and Lake Way (Brian Lancaster & Associates, 1981);
- Investigative studies for the purpose of the ERMP published in 2011 for the assessment of mining at Centipede and Lake Way (Toro Energy Limited, 2011c – Appendix 10.59); and
- Further investigations including ERICA and dust deposition modelling undertaken by Toro in relation to proposed mining at Millipede (Toro Energy Limited, 2015 – Appendix 10.34).

14.4 Proponent Studies and Investigations – Lake Maitland

Since 2007, baseline environmental monitoring of Lake Maitland has provided information on background radiation and radionuclide concentrations before the commencement of mining. This will aid in the derivation of appropriate environmental monitoring programs to assess any changes that may occur should mining be approved. The baseline monitoring included the collection and analysis of samples of sediment, soil, vegetation, groundwater and surface water for radionuclide concentrations.

Specifically, the following samples were collected:

- Groundwater at 16 locations north, south, east and west of Lake Maitland in seven sampling events from 2009 through to 2011;
- Surface soil from 10 baseline soil locations;
- Sediment from 10 baseline monitoring locations in 12 sampling events;
- Vegetation from 10 locations;
- Radon at 10 baseline monitoring locations;
- Radon progeny opportunistically across site; and
- Gamma readings from across the site.

Radionuclides analysed for the collected samples were uranium (as U^{238}) and the long-lived decay products. Since the ore at Lake Maitland is known to contain naturally occurring thorium (Th^{232}), the longer lived radionuclides within the Th^{232} decay chain were also considered.

Radon modelling was undertaken as part of an air quality impact assessment. The emission estimation was conducted to assess worst case operating conditions. Consequently, it was assumed that all identified surfaces would be exposed simultaneously and that all activities occur constantly throughout the designated time.

The former owner of Lake Maitland commissioned a risk assessment to estimate the potential impact of chemical or radiological releases on specific receptors (Golder Associates Pty Ltd, 2011f – Appendix 10.60). Toro commissioned a peer review of this assessment (Emission Assessments – 2014b – Appendix 10.44).

The air quality assessment at Lake Maitland (Golder Associates, 2011i – Appendix 10.66) and background ambient air quality monitoring undertaken at Lake Maitland (Golder Associates, 2011j – Appendix 10.67) have also been peer reviewed (Appendix 10.42 and Appendix 10.43 respectively).

14.5 Existing Environment – Millipede

14.5.1 Gamma Radiation

Sampling of gamma radiation levels using hand held meters has shown gamma dose rates ranging from 0.07 µSv/h to 0.86 µSv/h, with an average of 0.17 µSv/h. As expected, the higher dose rates were found in mineralized zones. Gamma levels in sand dunes were generally noted as about 0.1 µSv/h, which are consistent with the natural background levels observed in non-mineralised areas elsewhere in Australia.

During 2007, time integrated thermoluminescent dosimeters (TLDs) were used (including in the town of Wiluna, the Bondini Reserve and the Apex gold mine) for a period of three months. Results from the monitoring program gave average gamma level readings of 0.11 µSv/h (range 0.10–0.16 µSv/h). A second set of dosimeters was deployed for a six month period in 2008 giving a range of 0.10 µSv/h to 0.30 µSv/h. A third set of dosimeters was deployed for another six month period at the end of 2008 and the beginning of 2009, giving a range of 0.05 µSv/h to 0.11 µSv/h.

In 2010, Toro conducted an aerial radiometric survey of the region which provided broad regional mapping of gamma radiation levels. The survey was conducted by an aircraft which flew along transects at low height measuring gamma radiation at regular intervals of approximately 100 m with a highly sensitive detector. The detector measures the gamma radiation from the naturally occurring decay chains of uranium-238, thorium-232 and potassium-40 at an inferred height of 1 m from the ground, approximately every 100 m. The technique is usually used for identifying ore deposits, but also gives useful information for background (non-ore) locations.

Results of the aerial survey were verified with hand held gamma radiation detectors. This is known as 'ground-truthing'. A comparison of the aerial results with levels recorded from a hand held gamma monitor is presented in Table 14.1. It should be noted that the geometry of the sampling influences the results, with the aerial results averaging a wider area than the hand held results. The individual hand held results have been averaged to cover approximately similar areas.

Table 14.1: Comparison of aerial and ground-based gamma survey results

Gamma Range (µSv/h)	Average Aerial Results (µSv/h)	Average Measured Results (µSv/h)
0.06–0.08	0.07	0.07
0.08–0.10	0.09	0.09
>0.10	0.14	0.14

The background levels measured during the 2010 surveys show localised elevated gamma radiation levels above mineralized areas, as would be expected. Table 14.2 provides an example of gamma dose rates at other locations across Australia.

Table 14.2: Typical gamma radiation levels across Australia

Region	Gamma Levels (µSv/h)	Source
Central South Australia	0.1	BHP Billiton (2009)
Australian average	0.07	Inferred from ARPANSA (2005)
Rehabilitated Kalgoorlie Research Plant	0.07–0.18	DMP (2010a)
Typical for Australia	0.02–0.1	Mudd (2002)
Honeymoon Uranium Mine, South Australia	0.1	Kvasnicka (1998)

Uranium has been naturally accumulating in the Wiluna region for a long period of time and therefore gamma radiation levels are generally higher than in the surrounding areas, with typical gamma dose rates on the deposit ranging up to 0.86 µSv/h. Away from the deposits, gamma dose rates are 0.05 µSv/h to 0.16 µSv/h, which are similar to average dose rates in Australia.

14.5.2 Airborne Dust

Passive dust sampling usually measures the amount of dust depositing from the air, while active dust sampling measures the concentration of dust in air. While passive dust sampling is not directly comparable to dust in air results, it does provide more information on the atmospheric dust situation.

Active Sampling

As part of its baseline investigations, Toro sampled dust in the air in order to measure the typical radionuclide composition and concentration of radionuclides in naturally occurring dust. The same sampling locations used for measuring airborne and deposited dust were used for collecting samples to measure background levels of radiation in environmental dust.

Over a three year period, testing of radioactive constituents in airborne dust was carried out with samples collected using low volume sampling devices. Monitoring results are summarised in Table 14.3.

Table 14.3: Summary of low volume dust sampling (averaged over complete sampling period)

Location	Average Dust Concentration (μg/m^3)	Average Activity Concentration (μαdps/m^3)
~100 m east of mining area	7	43
~100 m north of controlled area	10	28
~100 m south of controlled area	5	41
~100 m west of controlled area	29	69
South of East Bore	4	26

Note: the unit μαdps/m^3 refers to micro alpha disintegrations per second per cubic metre and is a measure of the total long lived alpha radiation activity in air.

Dust Deposition Gauges (Passive Sampling)

Toro established a series of dust deposition gauges to measure passive dust at the Millipede/Centipede site as well as in other parts of the Project area. A series of 15 sites were established and are continuously monitored. Samples are collected monthly and sent for analysis. Due to the low levels of airborne dust in and around the Project area, and the lower concentration of radionuclides within the dust, samples are compounded over a two year period so that accurate results may be achieved. The locations of the dust deposition gauges are shown in Figure 14.1 and the total weight of dust collected over the monitoring period are presented in Table 14.4.

Figure 14.1: Locations of the dust deposition gauges

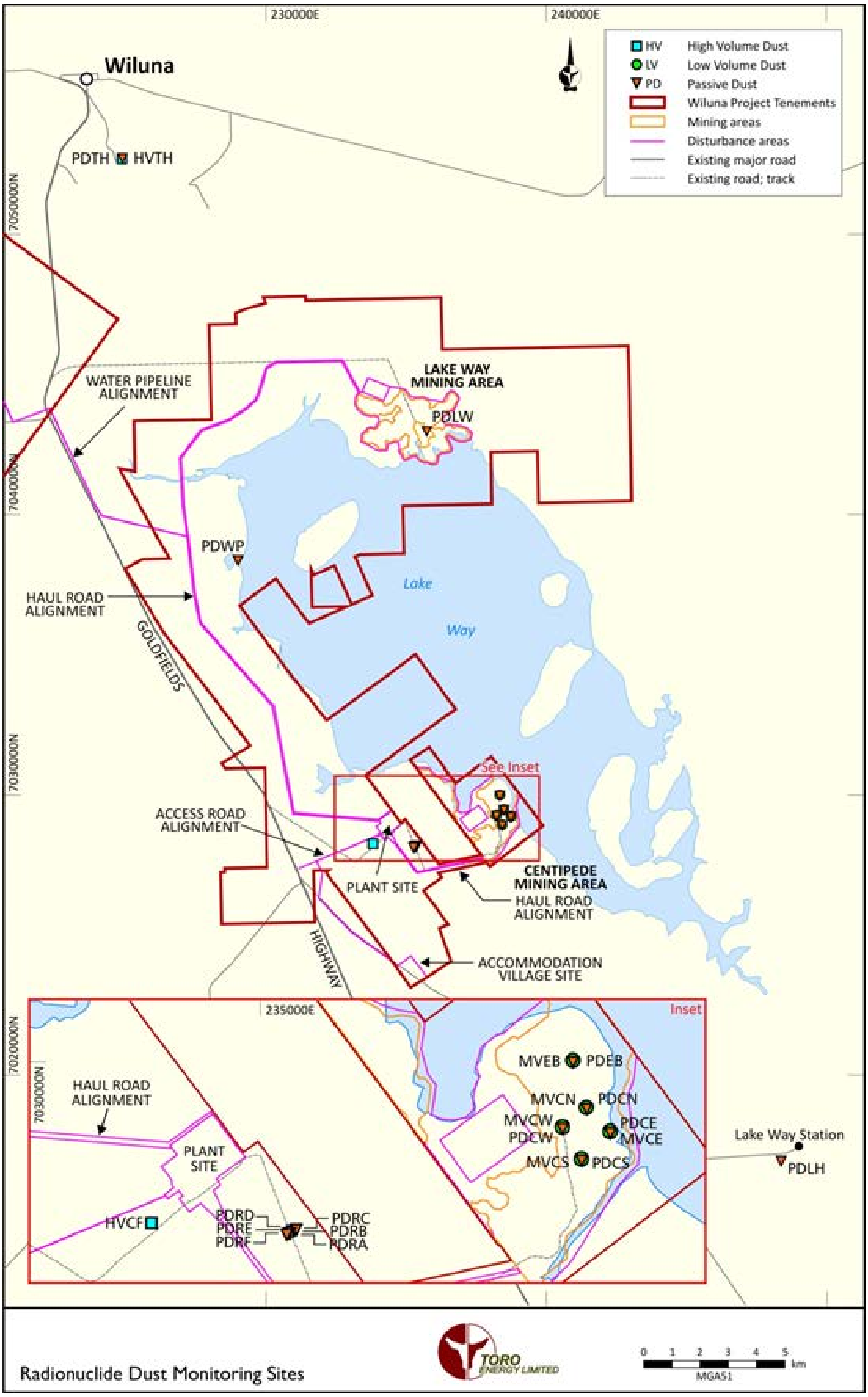


Table 14.4: Dust collection at dust deposition gauge sites

Site Name	Site Location	Dust Mass Deposited Over 2 years (g) and Average Dust Deposited per Month (g)	Site Name	Site Location	Dust Mass Deposited Over 2 Years (g) and Average per Deposited per Month (g)
PDTH	Toro House, just outside of Wiluna	0.759/0.032	PDRD	Adjacent to Millipede along access road	0.705/0.029
PDLW	Lake Way deposit	0.585/0.024	PDRE	Adjacent to Millipede along access road	0.628/0.026
PDWP	Williamson Pit, half way between Centipede and Lake Way	0.949/0.04	PDCE	Adjacent to Millipede along access road	0.598/0.025
PDLH	Lake Way Pastoral Station House	0.688/0.029	PDCW	West of the REP site	0.9/0.037
PDRA	Adjacent to Millipede along access road	0.665/0.028	PDCN	North of the REP site	0.574/0.024
PDRB	Adjacent to Millipede along access road	0.771/0.032	PDCS	South of the REP site	0.594/0.025
PDRC	Adjacent to Millipede along access road	0.745/0.031	PDEB	On the centipede deposit at the East Bore	0.0595/0.025

The results show that the levels of radionuclides in the dust are extremely low. Along the access road dust levels are highest close to the road and reduce with distance from the road, as would be expected (Table 14.5). The results for Pb^{210} and Po^{210} are elevated when compared to the other radionuclides. This is due to natural decay of radon in the atmosphere.

Table 14.5: Radionuclide concentrations in dust

Site Name	Units	Uranium 238	Uranium 234	Thorium 230	Radium 226	Lead 210	Polonium 210
PDTH	Bq/g	0.023	0.028	0.053	0.07	0.501	0.668
PDLW	Bq/g	0.028	0.0316	0.039	0.032	0.510	1.16
PDWP	Bq/g	0.044	0.042	0.0289	0.0168	0.360	0.55
PDLH	Bq/g	0.0221	0.0218	0.0444	0.0067	0.204	0.336
PDRA	Bq/g	0.0170	0.0136	0.056	0.0111	0.889	1.22

Site Name	Units	Uranium 238	Uranium 234	Thorium 230	Radium 226	Lead 210	Polonium 210
PDRB	Bq/g	0.0207	0.0240	0.036	0.0174	0.600	0.797
PDRC	Bq/g	0.0298	0.035	0.056	0.0200	0.616	0.67
PDRD	Bq/g	0.042	0.0289	0.036	0.0203	0.381	0.8
PDRE	Bq/g	0.0282	0.0386	0.0379	0.205	0.635	1.144
PDRF	Bq/g	0.065	0.077	0.060	0.0447	0.426	1.267
PDCE	Bq/g	0.0205	0.053	0.049	0.00176	0.635	0.901
PDCN	Bq/g	0.052	0.053	0.031	0.0207	0.454	1.16
PDCS	Bq/g	0.037	0.052	0.056	0.0177	0.412	0.980
PDCW	Bq/g	0.074	0.065	0.0378	0.0421	0.313	0.597
PDEB	Bq/g	0.036	0.038	.058	0.04	0.805	0.721

14.5.3 Radon

Environmental Radon Concentrations in Air

Radon is a naturally occurring inert gas that is ubiquitous in the atmosphere. It is produced from the decay of radium-226 (Ra^{226}) which is present in soils, rocks and water and which through diffusion, naturally makes its way into the atmosphere. Areas underlain by granite and areas where rocks contain elevated concentrations of uranium are typically associated with higher background concentrations of radon, because these materials (granites and uranium-bearing rocks) contain relatively high Ra^{226} concentrations.

Average concentrations of radon gas in the atmosphere vary depending upon a wide range of factors, including temperature, moisture, weather and the geology of the region. Typically, concentrations can vary between 1 Bq/m^3 and 1000 Bq/m^3 and the worldwide average is reported as 10 Bq/m^3 (UNSCEAR, 2000).

Under normal daytime conditions, the atmosphere is generally well mixed. However on calm nights stable atmospheric conditions result in temperature inversions which form quite close to the ground surface and any radon emanating from the soil may be trapped near the surface. Under such conditions, the radon concentration can increase rapidly to levels more than 100 times the normal daytime concentration before the stable conditions breakdown.

Radon Concentrations in the Lake Way Region

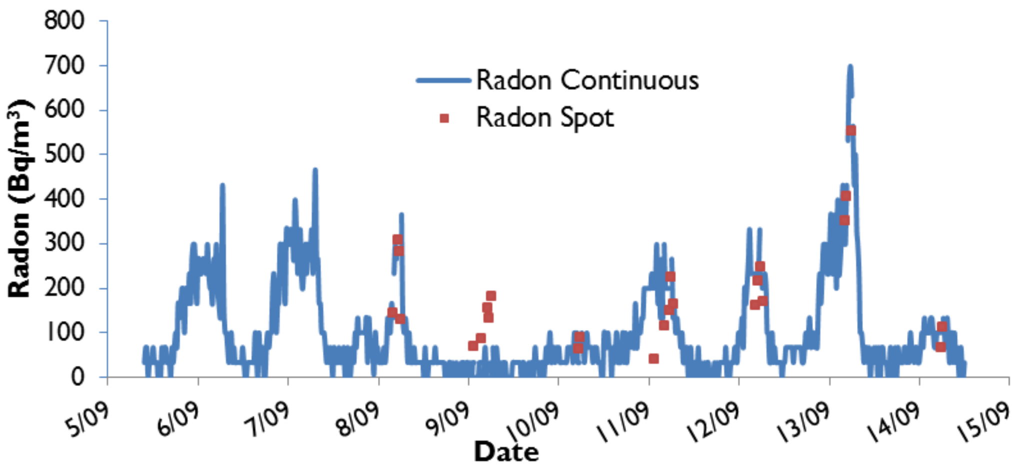
Radon concentrations have been monitored in the Wiluna region from time to time since the early 1980s. The main methods used for measuring radon have been:

- Grab Sampling: Sampling via Lucas Cells, the two filter tube method or 'radon sniffers' provides an instantaneous measurement of radon; and
- Continuous Monitoring: Active powered monitoring devices can either measure radon concentrations in real time or averaged over an extended period. Real-time monitors provide information on the natural variation that can occur in radon concentrations due to atmospheric conditions.

Passive track etch devices can also be used to provide a measure of the long-term average radon concentrations.

An example of historical radon monitoring results from both grab and continuous sampling carried out in the Wiluna region is shown in Figure 14.2. The figure clearly shows the diurnal (daily) changes in radon concentrations in air, with relatively low concentrations during the day (when the air is well mixed) and higher concentrations at night and in the early morning, when stable atmospheric conditions are more likely to occur.

Figure 14.2: Diurnal variation in radon concentrations in air



Source: Australian Atomic Energy Commission (1979)

Table 14.6 shows the results of historical radon sampling across the region undertaken by various parties. Again, the results support the notion of diurnal variation in radon over the course of the day, with the concentrations during the day hours being significantly lower than during the night hours.

Table 14.6: Summary of radon concentration measurements in the Wiluna region

Date	Location	Sampling Period	Average Radon Concentration (Bq/m³)	Comment
Sept 1979	Mine Site	0000–0800	180	Real time sampling by AAEC in 1979 (Note that sampling periods are as reported by AAEC)
		0800–1700	45	
		1700–2400	97	
		24 hr Average	101	
	Near mine Site	24 hr Average	75	
	Off mine Site	24 hr Average	101	
Aug 2007–Mar 2009	Regional	Total Average	21	Average of track etch detectors
	Mineralised areas		38	

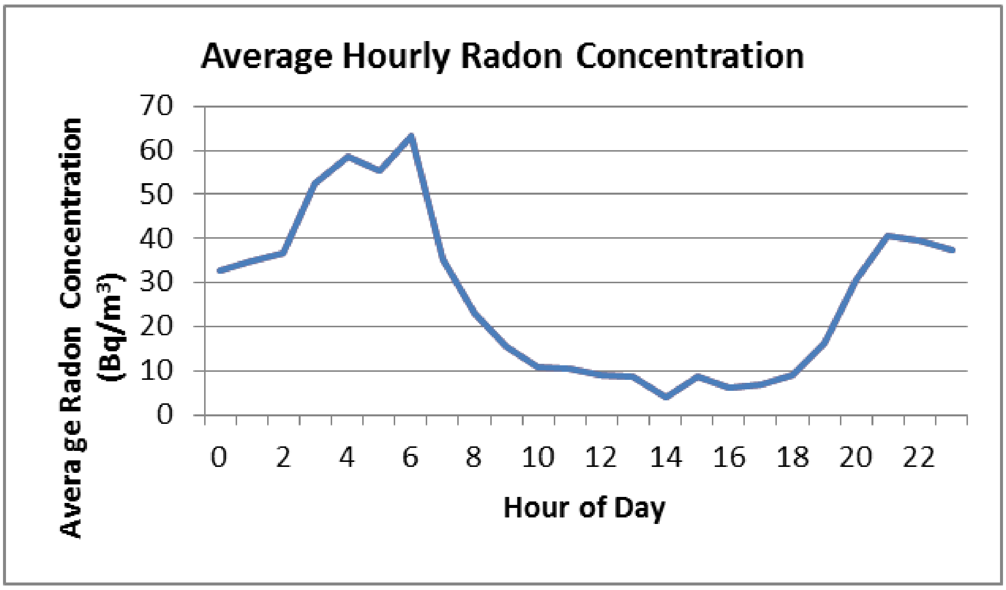
Work in the Wiluna region undertaken by the former Australian Atomic Energy Commission (AAEC) concluded that radon concentrations were naturally high due to two main factors:

- Higher radon emanation due to the region being a ‘broadly distributed source of radon’ because of the presence of near-surface uranium deposits; and

- The relatively stable atmospheric conditions that occur (particularly at night), causing radon concentrations to build up.

Toro conducted additional radon monitoring during 2010 to provide further detail on the naturally occurring background radon concentrations in the region (Toro, 2011a – Section 6.2). The more recent work confirms that radon concentrations vary diurnally as observed in the earlier AAEC work (Figure 14.3).

Figure 14.3: Average hourly radon concentrations at Lake Way (November 2010)



The average radon concentration in ambient air measured in November 2010 was 27 Bq/m^3. This is low compared to the historic AAEC results, but is consistent with the track etch results from 2007 to 2009.

The results of Toro's baseline radiation monitoring are consistent with results from radon monitoring at other uranium mines in Australia (Table 14.7).

Table 14.7: Radon at Australian uranium mining areas

Location	Reported Radon Concentrations (Bq/m^3)	Year of report
Lake Way	27	2011
Beverley	36	2003
Honeymoon	28	2003
Olympic Dam	20	2008

Source: Toro (2011a)

Radon Emanation

The amount of radon that enters the atmosphere from soil, rocks or uranium ore (radon emanation rate) varies depending on the type and radionuclide content of the source material. The results of the AAEC's investigations at various locations in the Wiluna region, including on the mineralised areas, non-mineralised areas and at distance from proposed mining areas are summarised in Table 14.8.

Table 14.8: Radon emanation

Location	Radon Emanation Rate (Bq/m^2s)
Regional (>3 km from mine area)	0.04
Outer region of mine (2–3 km from mine area)	0.14
Inner mine area (within 2 km of mine)	0.30

Source: AAEC (1979)

The concentration of radon in the air depends on the amount of radon being released from the surface ('emanation rate') and the amount of atmospheric mixing. The emanation rate is established by the radium content of the soil, which in turn determines the amount of radon being produced, and on the porosity of the soil, which determines the amount of radon that can diffuse into the atmosphere before decaying. The effective soil porosity can be altered by the moisture content and therefore this may also influence radon emanation rates (that is, emanation rates will tend to be higher in dry soil than in wet soil). Radon has a half-life of 3.8 days, so it can travel hundreds of kilometres before decaying. For this reason, concentrations of atmospheric radon can be influenced by emanation over a wide area.

Toro has undertaken additional sampling to determine the amount of radon emanating from different materials in the region, including soils and ores. Results of this work are shown in Table 14.9.

Table 14.9: Radon emanations – various substrates

	Measured Emanation Rate (Bq/m^2s)	Calculated Uranium Grade (mg/kg)
Unmineralised Calcrete	0.1	40
Unmineralised Soil	0.1	30
Clay	0.3	544
Ore Sample 1	0.2	268
Ore Sample 2	0.6	745

Source: Toro (2011a)

The radon emanation measurements show that the rate of radon emanation from ore is on average approximately 8 $Bq/m^2/s$ per %U. This is the figure that will be used in subsequent air quality modelling.

Summary of Background Radon Concentrations in Air

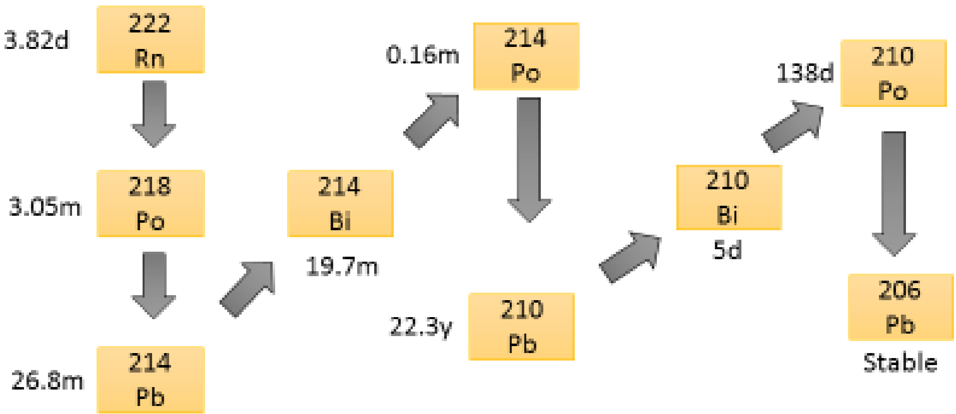
The Wiluna region has enhanced radon emanation due to the presence of near-surface uranium deposits. Stable atmospheric conditions (particularly at night) lead to build up of radon concentrations, with peak levels up to two to three orders of magnitude higher than the average range encountered during daytime. Daytime concentrations of radon in ambient air are generally within the range of variation experienced in many regions without significant uranium mineralisation.

Reported radon concentrations from mineralized zones (27 Bq/m^3) are similar to levels measured at Australian uranium mines and higher than the reported world average of 10 Bq/m^3 (UNSCEAR, 2000).

Radon Decay Products in Ambient Air

Radon decay products (RnDP) are formed from the decay of radon. The effective dose from radon itself is very small. The main health concern associated with radon is that radon acts as a transport mechanism for the RnDPs. Being a gas, radon moves with the air. Radon is radioactive and breaks down into short-lived isotopes (Figure 14.4) which are solid particles that, if inhaled, can deliver a radiation dose to the lungs.

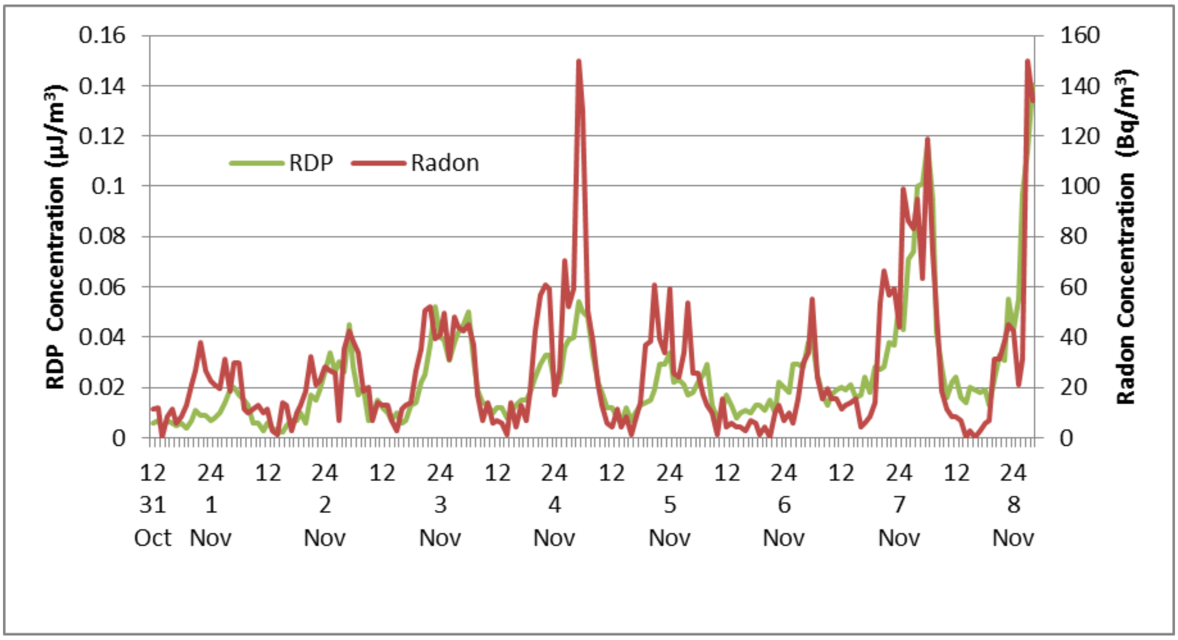
Figure 14.4: Radon decay product chain



RnDP concentrations in the Wiluna region have been measured by Toro using two different methods. Grab samples have been taken as part of an existing radiation monitoring program and active real time RnDP monitors have also been used.

Using real time monitoring equipment, Figure 14.5 shows the typical correlation between radon and RnDP levels. RnDP concentrations (like radon concentrations) are also directly affected by atmospheric conditions, which result in seasonal and diurnal variation.

Figure 14.5: Typical relationship between RnDP and radon (Centipede, November 2010)



The results of RnDP concentration monitoring carried out in the Wiluna region in 1979 are summarised in Table 14.10.

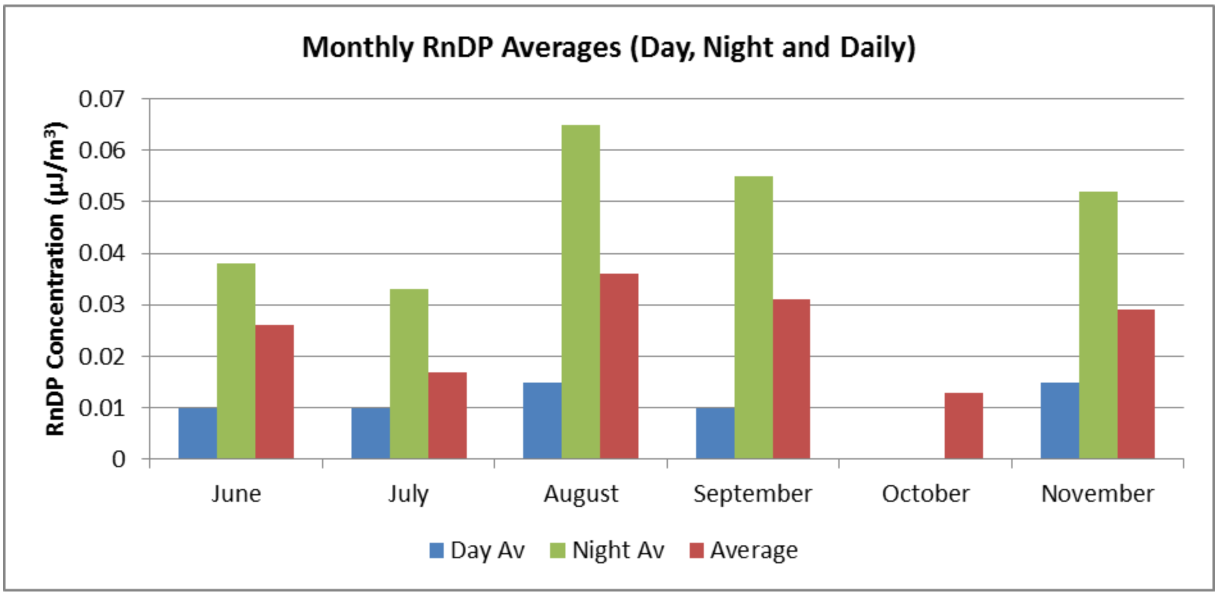
Table 14.10: Summary of RnDP concentration measurements (historical)

Date	Location	Sampling Period	Average RnDP Concentration (μJ/m^3)
Sept 1979	Mine Site	0000–0800	0.347
		0800–1700	0.033
		1700–2400	0.119
		24 hour average	0.148
	Near Mine Site	24 hour average	0.029
	Off Mine Site	24 hour average	0.054

During 2010, Toro used real time monitoring equipment to characterise RnDP concentrations in the Wiluna region. The sampling program utilised an environmental radon decay monitor (ERDM), which takes hourly measurements. The results of the monitoring show diurnal variation due to the effects of the stable atmospheric conditions at night, with RnDP concentrations peaking at almost 10 times the average daily concentrations.

Figure 14.6 shows average RnDP concentrations by month for 2010 (Toro, 2011a – Section 6.2). Averages are provided for: during daytime only, during night-time only and 24-hour averages. The results show that the average RnDP concentrations are between approximately 0.01 μJ/m^3 to 0.04 μJ/m^3.

Figure 14.6: Monthly average RnDP concentrations



Summary of RnDP Concentrations

Real time baseline RnDP monitoring was undertaken during the first half of the year, when still atmospheric conditions are common. These conditions usually result in elevated concentrations of radon and RnDP and therefore could be considered worst case RnDP conditions. RnDP concentrations are naturally elevated due to the metal-rich nature of the region. Typical average radon decay product concentrations in air are in the range 0.02 $\mu J/m^3$ to 0.03 $\mu J/m^3$. RnDP concentrations can peak at up to 10 times this level during night-time inversion conditions. Such wide variations in concentrations were relatively consistent across the region during the sampling period.

Radionuclides

Radionuclide Levels in Water

The Lake Way playa is a natural deposition basin for surface and groundwater covering an area of some 2200 sq km (Aquaterra, 2010a – Appendix 10.57). Groundwater monitoring and opportunistic surface water sampling has been conducted in the region to determine the pre-existing radionuclide concentrations.

Radiological testing of groundwater occurred in 1981, 2009 and 2010. Table 14.11 provides a summary of background radionuclide concentrations in groundwater.

Table 14.11: Radionuclides in groundwater

Date	Location	Ra^{226} (Bq/L)		Uranium (mg/L)	
		Range	Average	Range	Average
1981	Ore Zone	0.2–6.3	1.7	0.028–0.11	0.063
1981	Potable Water	<0.04	<0.04	0.0006–0.0012	0.0009
2009	Production Bores	5.6–7.7	6.4		
2009	Production Bores			0.05–3.4	0.19
2012	Regional Bores	0.03–1.58	0.06*	0.05–0.333	0.07
2010	Production Bores	0.03–0.12	0.064	0.02–0.15	0.07
2012	Production Bores	0.03–0.10	0.07	0.004–0.122	0.048

*Note: * The radium concentration for the solar bore is considered an outlier and so this has been removed from average calculations.*

It should be noted that groundwater near mineralized zones is unsuitable for human or stock consumption due to high salinity levels (up to three times the concentration of seawater). It is unlikely that any of the water would be consumed and therefore there is no pathway for potential exposure of people or livestock.

Monitoring from groundwater production bores shows that the pre-existing concentration of Ra^{226} in the groundwater is elevated. This is due to the localised uranium mineralisation. Uranium concentrations in groundwater are also elevated. Uranium is also elevated in the solar pump bore, which is located south-west of the Dawson Well deposit; however, it is not elevated in any of the other regional bores.

Radionuclides in Surface Water

The presence of natural surface water in the region is dependent upon rainfall and water flows into the lake system. Permanent water holes do not naturally exist, although after rains standing surface water is present. Surface water sampling shows that uranium levels at the edge of Lake Way are less than 0.08 Bq/L (Toro, 2011a – Section 6.2).

Long-lived Radionuclide Levels in Soils

Monitoring of radionuclides in soils in the region has been undertaken on a number of occasions. Concentrations in soils in mineralised zones are elevated. Radionuclide in soil monitoring from 1981 and 2007 is summarised in Table 14.12. The results show the impact of the mineralization with Ra^{226} concentrations being on average three to four times higher from soils within the mineralized zones. Uranium concentrations are also elevated.

Table 14.12: Historical radionuclide concentrations in soils

Date	General Area	Ra^{226} Concentration (Bq/kg)		Uranium Concentration (mg/kg)	
		Range	Average	Range	Average
1981	On mineralised zone	200–230	210	24–45	33
	Off mineralised zone	40–130	60	0.7–6.1	2.1
2007	On mineralised zone	30–400	190		
	Off mineralised zone	20–90	40		

Notes: Minimum detectable level for Ra^{226} was 40 in 1981 and 20 in 2007. No uranium analyses were undertaken in 2007.

Radionuclides in Soil Monitoring

In a 2010 sampling program, soils were analysed for the full suite of long-lived radionuclides from the U^{238} decay chain (being U^{238}, Th^{230}, Ra^{226}, Pb^{210} and Po^{210}) (Table 14.13).

The U^{238} and Ra^{226} concentrations are generally higher than the world median for soils of 35 Bq/kg (range 16–110 Bq/kg) for U^{238} and 35 Bq/kg (range 17–60 Bq/kg) for Ra^{226} reported in UNSCEAR (2000, Annex B). This is to be expected in a region like Wiluna with generally enhanced concentrations of uranium, radium and some other metals.

Table 14.13: Radionuclide concentrations in soils (from U^{235} decay chain)

Sources of Soil	Radionuclide Concentration (Bq/kg)					Number of Samples
	U^{238}*	Th^{230}	Ra^{226}	Pb^{210}	Po^{210}	
Off ore body (average)	50	30	60	90	90	4
Off ore body (range)	30–80	10–40	40–100	40–160	40–190	4
On ore body	530	330	750	790	730	1

*Note: * Inferred from Th^{234} analysis.*

Radionuclides in Vegetation

A baseline study of radionuclide concentrations in vegetation was conducted by Toro in 2010, with 30 vegetation samples collected and analysed. Half of the samples were long-lived *Acacia aneura* (mulga) and the remainder were the short-lived *Tecticornia*. Samples were analysed for Th^{234} (as an indicator of U^{238}), Th^{230}, Ra^{226}, Po^{210} and Pb^{210}. In addition, Ra^{228} and Th^{228} were analysed (from the Th^{232} decay chain). Uranium metal was analysed using mass spectrometry. Sample locations are shown in Figure 14.7 and results are summarised in Table 14.14.

Figure 14.7: Sampling locations for radionuclides in vegetation

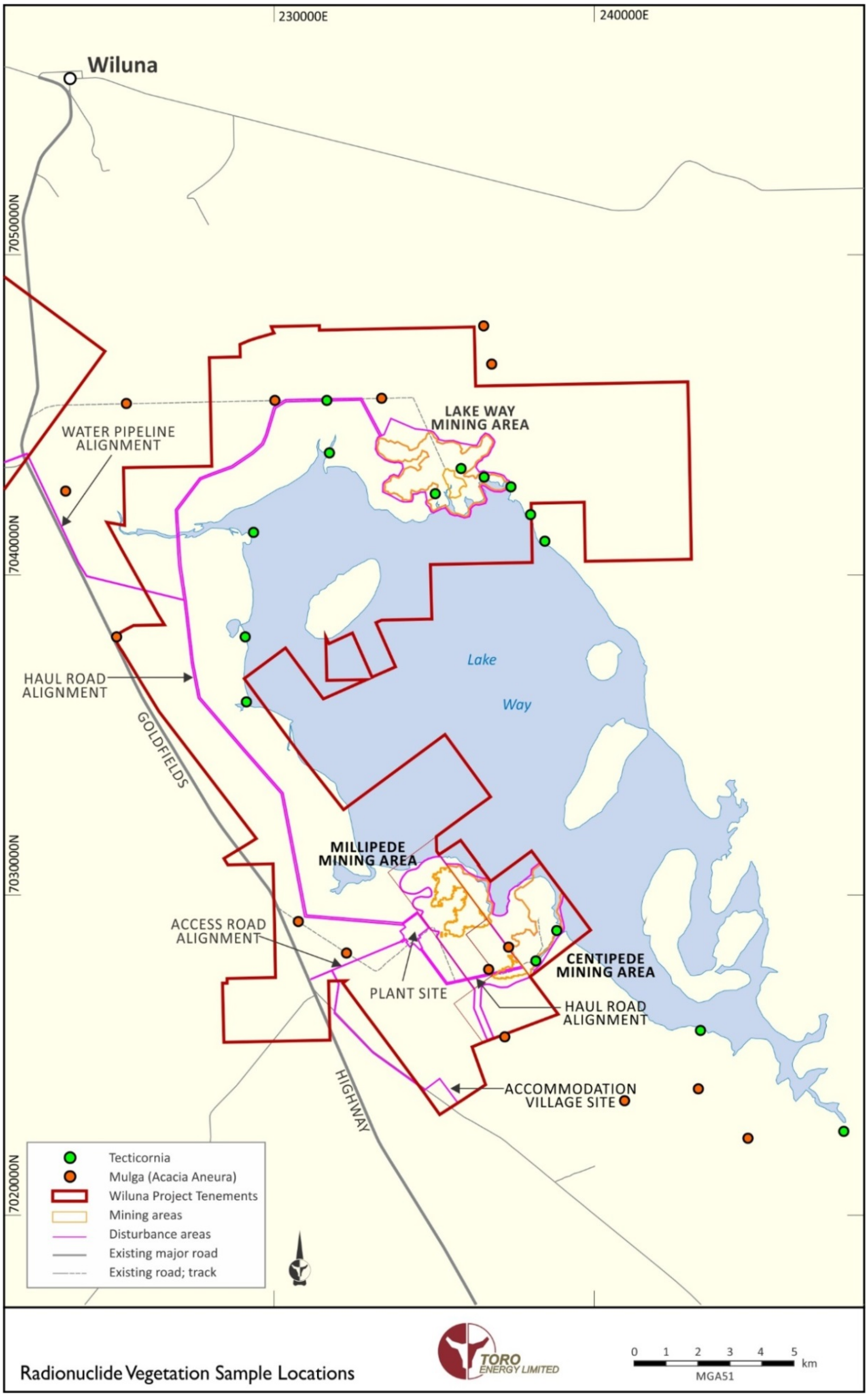


Table 14.14: Summarised vegetation analysis

Samples	Radionuclides (Bq/kg) (Average and Range)					
	U^{238}	Th^{230}	Ra^{226}	Pb^{210}	Po^{210}	Ra^{228}
Acacia (15)	9 (3–18)	1.0 (0.4–1.8)	2.5 (1.5–5)	95 (22–170)	52 (24 - 72)	2.1 (1–3)
Tecticornia (14)	0 (3–21)	8 (0.8–15)	4.6 (0.9–22)	30 (12–55)	31 (29–32)	2.2 (0.8–4)
From Ore Area (7)	12 (5–21)	7.7 (0.4–15)	6.7 (2.1–22)	31 (13–70)	28 (24–32)	2.2 (0.8–3)
Away from Ore Area (22)	9 (3–18)	1.2 (0.8–1.8)	2.5 (0.9–7)	74 (12-170)	54 (29–72)	2.1 (0.9–4)
Location A11 *Acacia* (1)	<41	-	5	750	-	<6

Source: Toro (2011a)

Earlier vegetation sampling was conducted for the 1981 EIS. A range of species were tested (Brian Lancaster and Associates, 1981) and Ra^{226} concentrations were below the detectable level (<40 Bq/kg). Uranium concentrations varied from a maximum of approximately 10 mg/kg (125 Bq/kg) in foliage at one location on the lake margin to 0.1 mg/kg to 0.2 mg/kg (1.25 Bq/kg to 2.5 Bq/kg) at sites remote from the lake shore.

Detection levels for the earlier samples for Ra^{226} are higher than the more recent results reflecting differences in the analysis techniques. Overall, the results from the earlier and more recent sampling are relatively consistent, excluding the lake margin.

Radionuclides in Fauna

Fauna samples from previous surveys in the Wiluna region have been reviewed and opportunistic sampling has occurred.

For the 1981 EIS, samples were obtained and a summary of the results is in Table 14.15. In 2010, a Bungarra (native monitor lizard) was accidentally killed on site by a vehicle, and was collected and sent for analysis.

Given the relatively close proximity between mining at Millipede and Lake Maitland and the ranges of the species already sampled, Toro has not considered it necessary or humane to undertake further fauna sampling for radionuclides.

Table 14.15: Radionuclides in fauna

Animal (Number)	Body Part	Year	U^{238} (Bq/kg)	Th^{230} (Bq/kg)	Ra^{226} (Bq/kg)	Po^{210} (Bq/kg)	Pb^{210} (Bq/kg)
Sheep (3)	Flesh	1981	0.62		0.75		
	Kidney	1981	1.5		1.8		
	Liver	1981	1.0		0.75		
Kangaroo (3)	Flesh	1981	0.62		0.6		
	Kidney	1981	0.62		0.6		
	Liver	1981	1.1		0.6		
Bungarra (1)	Tail	2010	<90	1.9	28	7.1	120
	Liver	2010	<50	2.8	55	80	55
	Bone	2010	<70	1.8	25	12.1	<80
	Skin	2010	<40	6.4	10.2	10.2	<40

Note: Results are reported as dry weight with uncertainty removed.

14.6 Existing Environment – Lake Maitland

14.6.1 Gamma Radiation

Baseline gamma monitoring was carried out in December 2006 and February 2007 and then again in January 2011. The 2006 and 2007 programs consisted of a 400 m grid survey, while the January 2011 survey was completed using a 100 m grid. A map of the local gamma measurements is provided in Figure 14.8.

The purpose of the surveys was to establish a radiometric map for the site for rehabilitation validation. The five minute integrated readings were converted to µSV/h. The sampling program is summarised in Table 14.16.

Table 14.16: Summary of gamma radiation measurements by location

Number of Locations	Frequency/Sample Events	Total Samples Collected	Comments
137	Single event	137	400 m x 400 m grid covering lake area
365	Single event	502	100 m x 100 m grid with 100 m interval transects

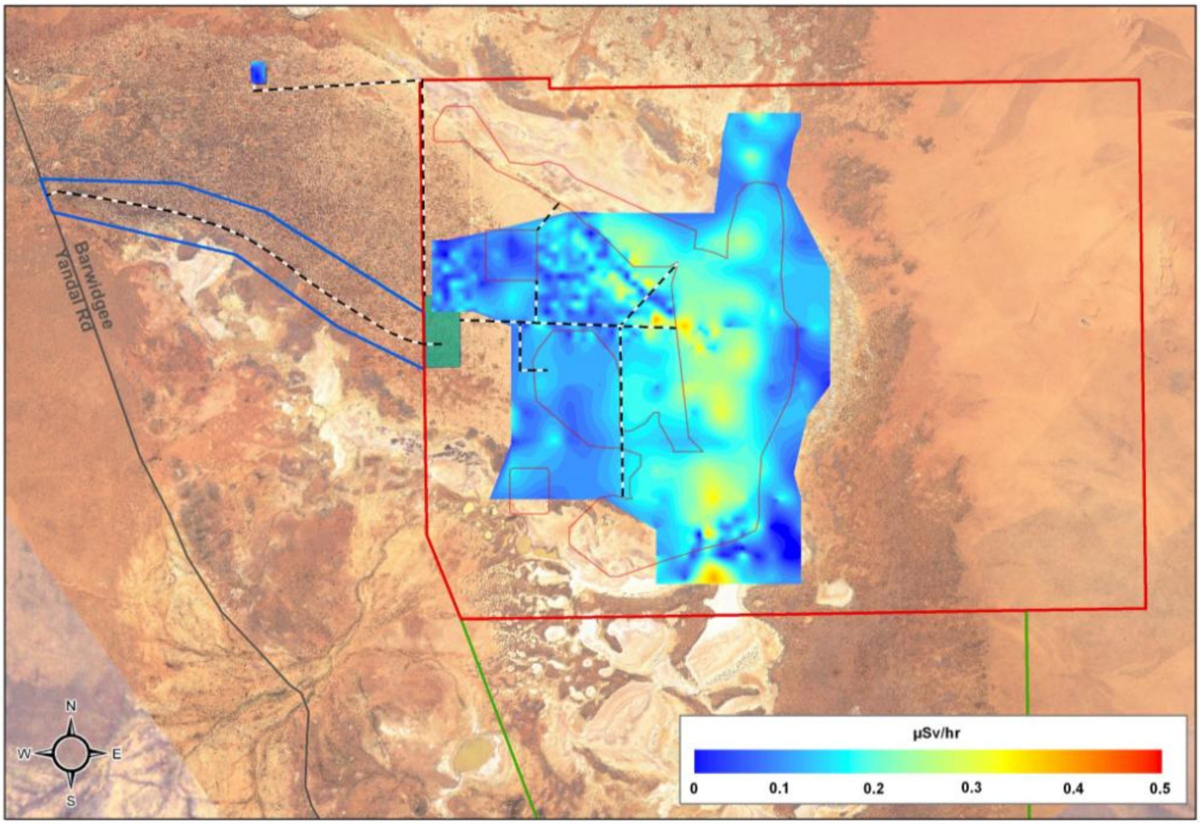
A total of 502 measurements were made. The gamma radiation levels ranged from 0.08 µSV/h to 0.36 µSV/h.

The mean gamma radiation levels for the areas surveyed are presented in Table 14.17.

Table 14.17: Summary of gamma radiation measurements by location

Location	Mean	Min (µSv/h)	Max (µSv/h)
Proposed Village	0.13	0.09	0.18
Site wide	0.16	0.08	0.36

Figure 14.8: Gamma survey across Lake Maitland



14.6.2 Radon and Radon Decay Products

An integrated approach to radon sampling was adopted to characterise the radon and radon progeny present, using grab samples and passive monitors. The locations of radon monitoring are provided in Figure 14.9. The outline of the ore body, consistent with that of the development envelope can be seen on the figure. Radon sampling was spread out across the development envelope area and a good coverage of the area in which the Proposal would be implemented was achieved.

The measurement of radon progeny concentrations is based on the detection of alpha particles emitted in the decay process.

Table 14.18 provides a summary of the radon in air sampling regime. The average concentration of radon was 69 Bq/m^3 with a minimum of 24 Bq/m^3 and a maximum of 192 Bq/m^3. During 2010, real time radon and radon decay product sampling was conducted at the Lake Maitland site using both active and passive sampling techniques. The results are consistent with those in the Lake Way region. Results from the sampling show that the radon in air around Lake Maitland was similar to that of Millipede. Again, high variations between day and night were seen, consistent with the findings at Millipede.

Figure 14.9: Locations of radon sampling – Lake Maitland

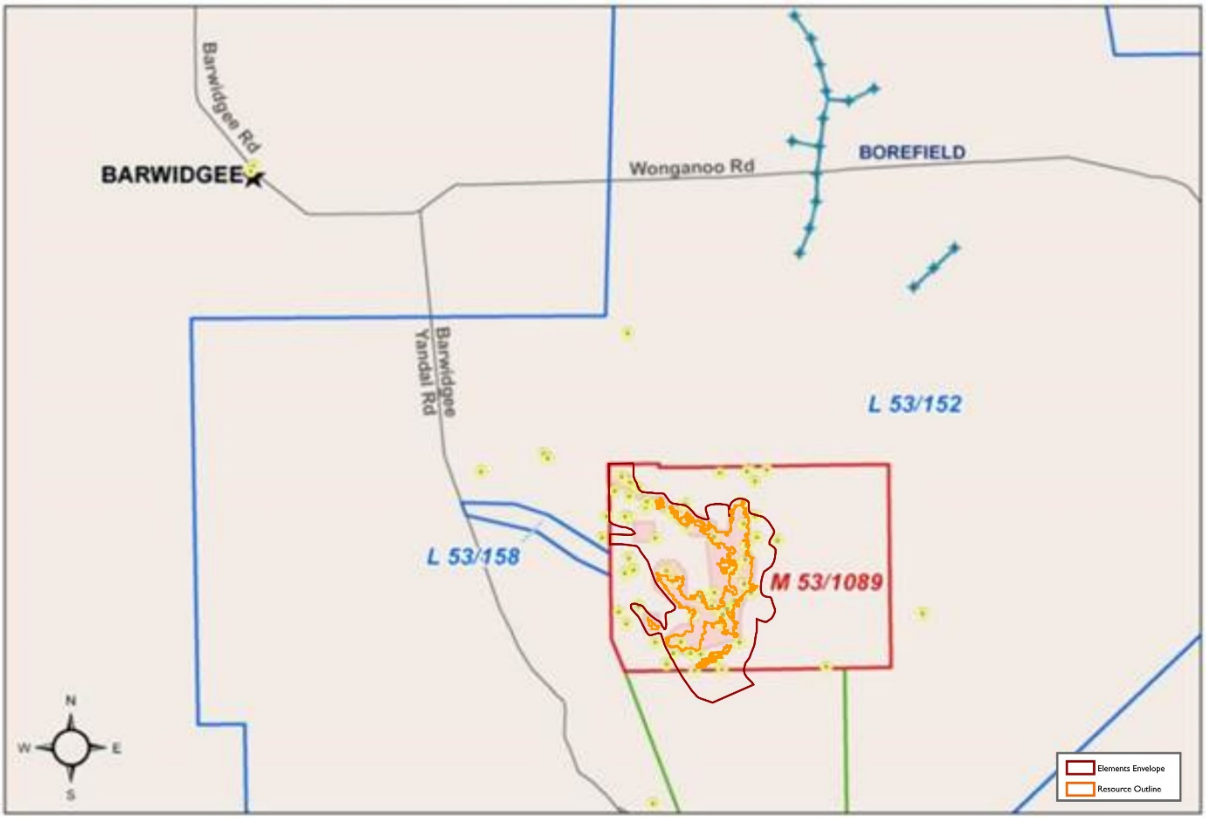


Table 14.18: Summary of radon in air baseline sampling – Lake Maitland

Component	Number of Locations	Frequency/ Sample Events	Events	Total Samples Collected	Comments
Passive Radon (PRM)	80	6 monthly	2 completed – 1 in field	80	
Passive Radon (E-Perm)	4	6 monthly	1 round in field	4	Co-located with selected PRM locations to be able to compare with PRM results
Radon Progeny	Approximately 15	Opportunistic sampling		15	These are the source of the radiation as they are alpha emitters
ERDM	11 critical group locations	Opportunistic sampling	11 events	11	Co-located with PRM or the critical group

14.6.3 Groundwater

The groundwater monitoring program consisted of the collection of samples from 16 monitoring wells.

Sampling was conducted with the collection of representative primary, duplicate, triplicate and reinsate water samples that were submitted to a National Association of Testing Authorities (NATA) accredited laboratory for analysis.

Samples collected from a reduced number of wells were analysed for Ra^{226} and Ra^{228} as these analytes entail relatively large sample volumes. The samples were selected based on geological variability and the measured variability in pH and redox conditions in the water column.

A summary of the baseline groundwater data is provided in Table 14.19.

Table 14.19: Baseline groundwater radionuclide data – Lake Maitland

Constituent	# of Results	LOR	Max	Mean	Median	Livestock Drinking Water	Fresh Water Quality Trigger Value	Marine Water Quality Trigger Value
Gross Alpha	30	0.005	1280	72	0.32	0.5	NG	NG
Gross Beta	31	0.01	112	8.5	0.79	0.5	NG	NG
Th^{230}	50	0.1	72.9	1.9	0.08	NG	NG	NG
Ra^{226}	50	0.003	39	5.1	1.845	5	NG	NG
Pb^{210}	50	0.1	48.4	3	0.127	NG	NG	NG
Po^{210}	50	0.1	4.53	0.48	0.15	NG	NG	NG
Ra^{228}	50	0.1	2.76	0.65	0.446	2	NG	NG
Rn^{222}	52	0.003	1900	346	148	NG	NG	NG
K^{40} (mg/L)	15	NR	3200	1907	1700	NG	NG	NG

Notes: LOR = Limit of Reporting; All values in Bq/L; All samples are filtered samples; Shaded cells indicate that baseline maximum concentrations are elevated above livestock drinking water criteria, NR- No Result, NG- No Guideline

A comparison of the filtered groundwater samples with ANZECC trigger values for metals indicated:

- Maximum baseline concentrations of Ra^{226}, Ra^{228}, gross alpha and gross beta were elevated compared with livestock drinking water trigger values; and
- Maximum baseline concentrations of uranium were elevated compared with the guideline value which is less than the limit of reporting.

Analysis of surface water quality has not been undertaken as part of this PER. Lake Maitland is an ephemeral lake and only fills after periods of significant rainfall. As the Lake Maitland deposit is situated inside the lake, access to the region after periods of rainfall heavy enough to run into the lake has not been possible. As surface water flows into the lake do not come into contact with any uranium mineralisation elsewhere in the catchment, it is expected that uranium and other radionuclide concentrations in surface water would be extremely low.

14.6.4 Soils

Surface soil sampling was undertaken at the locations where vegetation samples were collected. A summary of the baseline soil data for non-radionuclide chemicals compared to human health and ecological screening levels is provided in Table 14.20. None of the maximum metal concentrations measured in the baseline survey exceeded the relevant screening levels.

Table 14.20: Summary of baseline soil sampling – Lake Maitland

Constituent	No. of Samples	Maximum	Median	Average	Ecological Screening Levels	Human Health Screening Levels
Non-radionuclides						
Aluminium	11	50,400	18,500	23,055	NST	99,000*
Antimony	11	<0.2	<0.2	<0.2	NG	410*
Arsenic	11	6.1	2.3	3	20	200
Barium	11	87	41	42	300	19,000*
Beryllium	11	0.7	0.5	0.34		40
Boron	11	<1	<1	<1		6000
Cadmium	11	<0.1	<0.1	<0.1	3	40
Chromium	11	43	21	20	400	240,000
Cobalt	11	7.7	2.8	3.3	50	200
Copper	11	24	8.5	11	100	2000
Iron	11	36,000	13,200	16,836	NST	NST
Lead	11	14	4.7	6.3	600	600
Manganese	11	380	100	129	500	3000
Mercury	11	<0.05	<0.05	<0.05	1	30
Molybdenum	11	1.6	0.2	0.34	40	390+
Nickel	11	24	11	14	60	600
Selenium	11	0.7	0.2	0.31	0.23#	5100*
Silver	11	0.3	<0.1	0.23	NG	NG
Strontium	11	210	71	74	NG	610,000
Tellurium	11	<0.5	<0.5	<0.5	NG	NG
Thallium	11	<0.2	<0.2	<0.2	NG	NG
Thorium	11	12	3.7	4.6	NG	NG
Tin	11	0.7	0.3	0.29	50	47,000
Titanium	11	900	360	475	NG	NG
Uranium	11	30	1.6	4.2	23#	3100*
Vanadium	11	77	30	35	50	550
Zinc	11	40	13	19	200	1400

Constituent	No. of Samples	Maximum	Median	Average	Ecological Screening Levels	Human Health Screening Levels
Radionuclides						
Pb-210	11	160	80	98	NG	NG
Po-210	11	180	45	68	NG	NG
Ra-226	11	370	50	110	NG	NG
Ra-228	11	60	60	60	NG	NG
Th-228	11	50	35	35	NG	NG
Th-230	11	350	45	85	NG	NG
Thorium-232	11	80	30	36	NG	NG
Uranium	11	30	1.6	4.1	NG	NG

Notes: 1. All data in mg/kg except for radionuclides that are expressed as Bq/kg
*2. All human health screening levels are Human Health Investigation Level (HIL) unless denoted with * which indicated they are US EPA Regional Screening Levels for residential recreation parkland land use or + which denotes HILA for residential use*
3. All ecological screening criteria are HIL unless denoted with # which indicates they are US EPA Soil Screening Levels.
4. Shaded cells indicate that the baseline maximum concentration is elevated above ecological screening levels.
5. NST – Not to be Sufficiently Toxic.
6. NG – No guideline.

The values of radionuclide concentrations in soils are similar to those found at Millipede. This reflects the similar grades of the deposit and the composition of the host rock.

14.6.5 Vegetation

Vegetation samples were analysed for radiological characteristics. As there are no critical vegetation groups in the vicinity of areas to be disturbed at Lake Maitland, reference vegetation samples were used to measure uptake of radionuclides from the environment. A summary of the results is provided in Table 14.21.

Table 14.21: Summary of vegetation samples taken at 10 Critical Group locations – Lake Maitland

Variable	Number of Samples	ND	Minimum	Maximum	Mean
Th-234	8	0	3	11	5.5
Ra-226	8	7	1.4	3	2.0
Pb-210	8	0	44	99	67
Po-210	8	0	36	65	51.4
Elemental U (mg/kg)	8	0	1.2	1.5	1.3
Ra-228	8	1	0.9	3	1.5
Tho-228	8	0	0.3	2.5	1.2
Elemental Th (mg/kg)	8	0	1.2	1.5	1.3
K-40	8	0	68	169	130.8
Be-7	8	0	46	78	62.7

Note: Units are Whole-sample activity concentration in, except for Elemental U and Th = (mg/kg); ND = not detected; Minimum, maximum and mean concentrations are Bq/kg.

14.6.6 Radionuclide Concentrations in Sediments

At Lake Maitland, baseline sediment sampling for radionuclides was undertaken at 10 monitoring locations. Samples were taken from the top 2 cm of the soil profile with appropriate QA/QC procedures. The samples were analysed at a NATA certified laboratory.

Table 14.22 provides the results of the sampling, while Figure 14.10 shows the sampling locations. The results show large variations in the concentrations of radionuclides and gross alpha and beta radiation, likely due to the sampling locations. The results show that sediment radionuclide concentrations are elevated when compared to world background levels and the highest readings are up to an order of magnitude higher than the lower readings. This is due to the enhanced concentration of uranium across the mining areas. All results in the table are presented as Bq/kg unless otherwise specified.

Table 14.22: Radionuclide concentrations in sediments

Constituent	Number of Samples	LOR	Minimum Concentration	Maximum Concentration	Average Concentration
Gross Alpha	10	500	750	4370	2157
Gross Beta	10	500	520	2140	1109
Potassium 40	10	10	50	260	161.1
Lead 210	10	50	63	64	63.5
Radium 226	10	1	4	201	56.7
Radium 228	10	1	7	21	12.2
Thorium 228	10	1	6	31	15
Uranium 238	10	10	18	330	128.1
Thorium mg/kg	120	0.1	<0.1	4.8	1
Uranium mg/kg	120	0.1	<0.1	94.4	9.2

14.6.7 Radionuclide Concentrations in Dust and Air

Dust radionuclide levels are a result of mineralised surface material being picked up by wind. Dust radionuclide concentrations can be calculated using the sediment sampling results when coupled with dust deposition and TSP results.

Dust deposition gauges and dichotomous samplers were established at the Barwidgee Pastoral Station and the Lake Maitland Exploration Camp. Other dust deposition gauges were established across the mining area (Figure 14.10). The results of the airborne dust monitoring are presented in Table 14.23.

Figure 14.10: Lake Maitland sediment sampling and dust monitoring locations

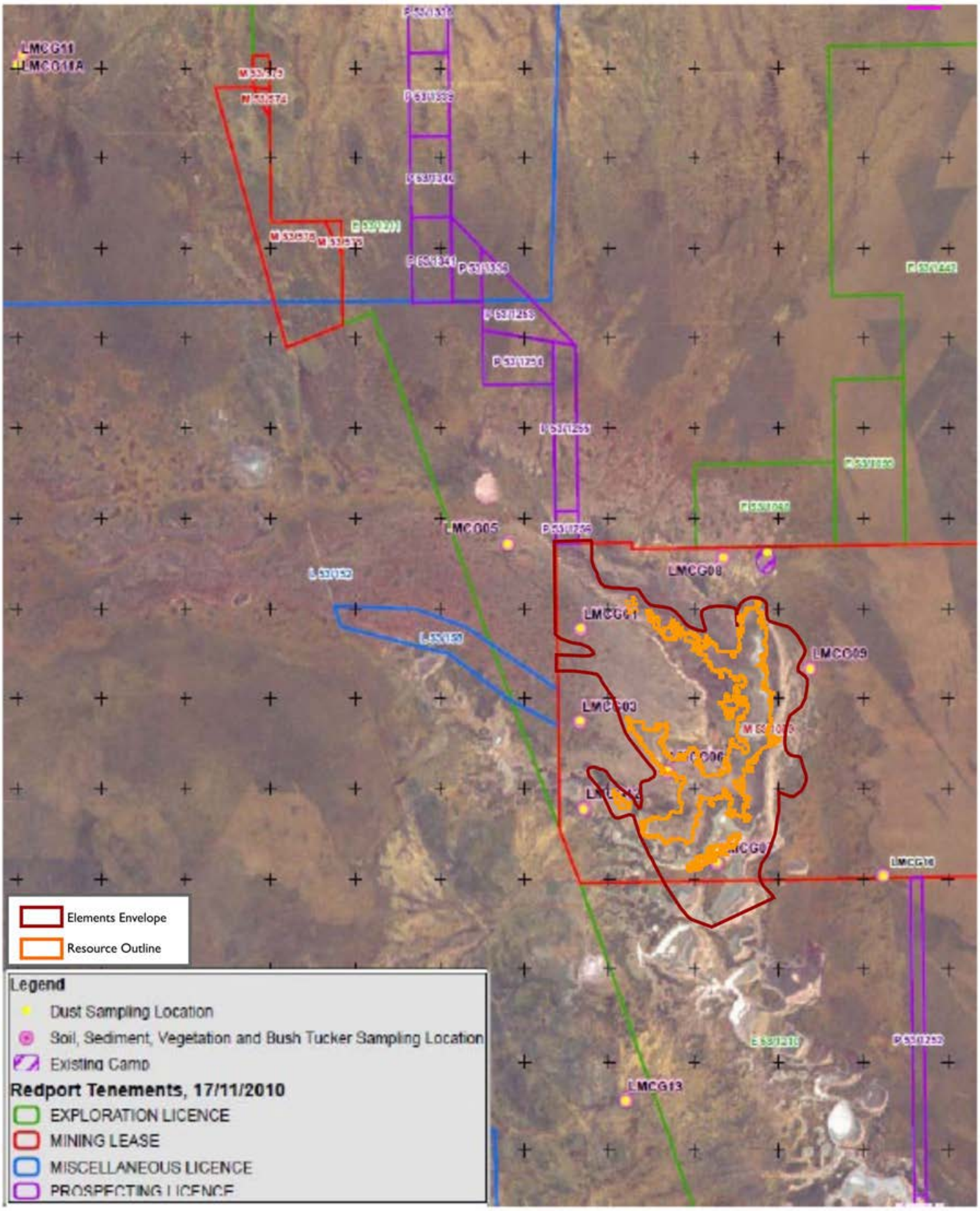


Table 14.23: Airborne dust monitoring – Lake Maitland

Atmospheric Contaminant	Average Period	Background Levels	Criteria
Units		**µg/m³**	**µg/m³**
TSP	24h	39	90
PM_{10}	24h	19	50
$PM_{2.5}$	24h	17	25
	1yr	2.4	8
Units		**g/m²/month**	
Deposition Rate	1 month	2.0	4

The concentrations of radionuclides in air and dust were calculated using the minimum, maximum and mean radionuclide concentrations and are presented in Table 14.24.

Table 14.24: Radionuclide concentrations in air and dust – Lake Maitland

Radionuclide		Concentration (Bq/kg)	Activity Deposited per Month (Bq/month)	Activity in Air (µBq/m³)
Potassium 40	Max	260	0.52	10.14
	Min	50	0.1	1.95
	Ave	161.1	0.32	6.28
Lead 210	Max	64	0.13	2.50
	Min	63	0.13	2.46
	Ave	63.5	0.13	2.48
Radium 226	Max	201	0.4	7.84
	Min	4	0.01	0.16
	Ave	56.7	0.11	2.21
Radium 228	Max	21	0.04	0.82
	Min	7	0.01	0.27
	Ave	12.2	0.02	0.48
Thorium 228	Max	31	0.06	1.21
	Min	6	0.1	0.23
	Ave	15	0.04	0.58
Uranium 228	Max	330	0.66	12.87
	Min	18	0.04	0.70
	Ave	128.1	0.26	4.99

The radionuclide concentrations are comparable with the results achieved across the Millipede and Centipede deposits. This is due to the similar depth and concentration of the deposits and the similar environmental setting.

14.6.8 Fauna

No radionuclide data is available for fauna species taken at Lake Maitland. Radionuclide information is available for the wider region, including at Wiluna, (see above under Radionuclides in Fauna) as well as from uranium projects elsewhere in Australia. A study undertaken at the Ranger Mine in the Northern Territory found that the concentration of radionuclides in various fauna species was an order of magnitude lower than in the Wiluna region (Martin *et al.,* 1998). Further studies undertaken by Johansen and Twining confirmed that the radionuclide concentrations in native Australian fauna are higher in arid regions when compared to data in temperate regions (Johansen and Twining, 2009). The findings of these two studies combined with other data obtained by Toro would suggest that there is likely to be no difference in radionuclide concentrations in species across the Lake Way and Lake Maitland region. Prior to the implementation of the Proposal, Toro will endeavour to undertake opportunistic radionuclide sampling from fauna when events such as vehicle strikes occur.

14.7 Potential Impacts – Millipede and Lake Maitland

The Millipede and Lake Maitland deposits are very similar in grade and therefore the operation at both would mine to a similar ore grade cut-off. Accordingly, the impacts of mining similar uranium grades are expected to be common between the two sites.

It is recognised that very high doses of radiation can destroy cells in sensitive organs or tissues, possibly resulting in death or serious illness. However, doses from uranium mining do not approach the levels that would induce such effects.

Cellular damage may potentially occur from lower doses of radiation, but there are cellular mechanisms which repair such damage or eliminate damaged cells. While international guidelines and recommendations mandate an approach to radiation protection which ensures that doses are kept as low as reasonably achievable (social and economic factors taken into account), to acknowledge the theory that even low doses of radiation may potentially increase the risk of cancer, studies have shown that doses below about 50 mSv do not increase the risk of cancer.

14.7.1 Mitigation Hierarchy

While the mitigation hierarchy of avoid, minimise, reduce and rehabilitate is appropriate for managing the risks associated with some key environmental factors, it is not readily applicable to risks associated with radiation.

Instead, in this assessment the ALARA principle has been applied to keep risks as low as reasonably achievable. The following section outlines the radiation risks associated with the Proposal and how Toro plans to manage those risks consistent with application of the ALARA principle.

14.7.2 Overview of Pathways of Potential Impacts

Receptors may be subjected to low level radiation exposures through a number of pathways. The primary radiation exposure pathways associated with this Proposal are:

- Exposure to direct external gamma radiation from ore and mineralised overburden;
- Inhalation of radon gas and radon progeny;
- Exposure to ground and surface waters that contain elevated uranium and radionuclide concentrations associated with mining of either deposit;
- Inhalation of long-lived radioactive dust (LLRD); and
- Ingestion of long-lived radioactive material.

Gamma Radiation

Workers and contractors who spend time adjacent to the ore and mineralized waste rock would receive gamma radiation exposures. For a mechanised mining operation such as that planned for Millipede and Lake Maitland, some of the gamma radiation would be blocked by the steel surrounding the operator's compartment of the mobile mining equipment. Another important part of gamma radiation control would be to minimise the time workers spend close to sources such as large ore stockpiles or the ore body.

Radon

Radon and radon progeny are produced by the decay of Ra^{226} and its immediate radioactive progeny. Consequently, radon gas and its progeny would be released at Millipede and Lake Maitland from:

- The exposed ore and groundwater within the open pits; and
- The ore stockpiles.

As the mine would be open to the atmosphere, the radon would disperse quickly into the air and dissipate. General experience at other uranium mines is that radon presents a hazard when it is confined within an underground mine. There was some evidence of slightly elevated concentrations of radon within costeans during the exploration phase at Lake Maitland. This has been taken into account in the mine design for both Millipede and Lake Maitland, and the projections of employee radiation exposure during mine operations.

Exposure to Waters with Elevated Uranium or Radionuclide Concentrations

The potential for members of the public or livestock to be exposed to ground or surface waters with elevated uranium or radionuclide concentrations is low. There are no permanent surface water flows within the Project area, and surface water only flows after periods of sustained rainfall. Surface water flows towards both lakes, which act as a regional groundwater sink (RPS, 2015a – Appendix 10.1; and Pennington Scott, 2015b – Appendix 10.30). Surface waters that would normally pass the Millipede deposit as they flow through Abercromby Creek would be diverted through an upstream tributary of the creek. This would ensure maximum separation of the Project from surface water flows. Around mine pits and stockpiles bunds would be established. These would have the primary purpose of protecting the mine from flood events, and would also serve to keep surface water flows outside of operational areas. Diversions around infrastructure would ensure that surface waters do not interact with the mining activities in any form. Once surface waters mix with the lake sediments, they dissolve the crust of salt that is present on the lake surface and become unsuitable for drinking by humans or livestock. Accordingly, they do not provide a pathway for exposure to uranium or radionuclides.

Groundwater flows into Lake Way from the north-west to the south-east (RPS, 2015b – Appendix 10.56) and at Lake Maitland groundwater from all directions flows towards the lake. Migration of groundwater away from the lakes has been shown to be impossible based on the modelling undertaken by Toro. Instead, the lakes form a terminus for groundwater through which it is evaporated. The groundwaters across both lake systems are hypersaline and commonly exhibit salinity levels of well over 80 g/L. For this reason, groundwaters are unsuitable for human or livestock consumption and so a pathway to exposure does not exist.

Inhalation of Airborne Long-Lived Radioactive Dust

Uranium ore contains 14 different radioactive isotopes with a wide range of half-lives, including radon and radon progeny. It will be necessary to control inhalation of any of these isotopes, with the main consideration being ore dust.

Ingestion of Long-lived Radioactive Material

Within the Millipede and Lake Maitland mine sites, quantities of loose (or unsealed) radioactive material would be stored. Any worker ingesting such material would receive a radiation exposure. The general experience at uranium mines is that ingestion of radioactive material is not a significant radiation exposure pathway. In part, this is because of the stringent industrial hygiene practised, with strict segregation of clean areas from those which may contain radioactive material. The provision of clean lunchrooms, careful monitoring for the presence of radioactive material and adequate washroom/shower facilities would prevent the inadvertent ingestion of radioactive material.

14.7.3 Overview of Critical Groups

Modelling and investigations have not identified any 'Critical Groups' within the vicinity of proposed mining at Lake Maitland, as defined by the DMP's Managing NORM Guidelines (DMP 2010b). Non-critical group receptors of interest in relation to radiation are:

- Mine employees, contractors and occupants of the accommodation village: All employees and contractors undertaking activities on site would be housed at the accommodation village for the duration of their rosters.
- Collectors of bush tucker on Barwidgee Station: Aboriginal people have used Lake Maitland for collection of bush tucker and other traditional pursuits, and would continue to do so. Although activity is infrequent and can depend on seasonal factors, it has been assumed that a population group could use an area at the boundary of the mine lease and receive a minor radiation dose.
- Occupants of Barwidgee Homestead: There are no permanent residents within a 10 km radius of where mining would be undertaken at Lake Maitland. The nearest population group is at Barwidgee Homestead followed by Wonganoo Homestead, Bronzewing Gold Mine (currently on care and maintenance) and Mt Keith Nickel Mine. Both the Barwidgee and Wonganoon Homesteads have a small group of permanent residents and some transient residents, including seasonal pastoral workers and visitors. The nearest population centre to Lake Maitland is Leinster (population 1294 at the 2011 Census). None of these population groups is likely to receive a measurable radiation dose attributable to mining at Lake Maitland.
- Non-human biota, including livestock: At Lake Maitland, the following is a summary of non-human biological receptors identified by ecological surveys (Golder Associates Pty Ltd, 2011f – Appendix 10.60):

- Receptors potentially affected include terrestrial plants, soil, fauna, aquatic invertebrates, birds and mammals. Each category encompasses a range of functional groups such as terrestrial plant-eaters (herbivores) and terrestrial animal-eaters (carnivores) that differ by habitat utilisation and preferred foods. The particular species composition of aquatic and terrestrial communities varies among habitats at Lake Maitland.
- Fauna range from small herbivorous mammals that could complete their entire life cycles in small home ranges to migratory, nomadic or irruptive species that may forage on the salt lake during a particular season or favourable climatic conditions. Larger-bodied herbivorous and carnivorous mammals that roam widely in search of food may also use the area.
- Standing water may attract larger mammals from the surrounding landscape seeking drinking water. Such ponds may also be found and used by waterbirds moving within the broader region during significant rainfall events. Other locally occurring small terrestrial vertebrates (small birds, small mammals, reptiles and frogs) generally have small home ranges and will not necessarily be attracted to water sources involving movement away from home ranges.
- Benthic invertebrates may be common following the occurrence of ponded water after rainfall. Birds, frogs and other biota may feed on the invertebrates.

The receptors identified during the previously assessed Wiluna Uranium Project (EPA Assessment 1819 and EPBC 2009/5174 – Toro Energy, 2011a – Section 6.2) remain relevant to mining at Millipede under this Proposal.

14.7.4 Occupational Dose Assessment – Method of Assessment

In making dose assessments, the main exposure pathways have been considered, with exposure estimates based on:

- Consideration of emissions modelling;
- Calculation from first principles;
- Review and interpretation of occupational monitoring results to date; and
- Comparison with actual doses from similar operations.

Dose estimates have been made for the following main worker exposure groups:

- Miners;
- Plant operators; and
- Product packers.

An estimate of doses for administration, construction and transport workers has also been made. These doses would be much lower than the other workgroups described above, and less than the member of the public dose limit of 1 mSv/a above natural background levels.

Miners

The planned mining operations at the Millipede and Lake Maitland deposits are similar, with similar quantities of materials being mined on an annual basis utilizing the same mining techniques, mining fleet and operators.

Dose estimates to miners have been based on mining involving a relatively small workforce (up to 200 during operations) and being conducted 24 hours a day, seven days a week on a continuous 12-hour shift roster. No drilling and blasting activities are anticipated. The mining fleet requirements are yet to be optimised, but would include surface miners, articulated dump trucks, excavators, front end loaders, graders, service trucks and light vehicles. A typical mining shift would involve equipment operators as shown in Table 14.25.

Table 14.25: Mining shift numbers (estimated)

Equipment	Operators/shift
Scrapers/Surface Miners	2
Trucks	4
Excavators	2
Dozers	2
Others	10

Other workers would be involved in the mining operations, including supervisors, geologists, pit technicians/surveyors and environmental and safety officers. The full-time miners predominantly would be equipment operators. Mining personnel would have the highest exposures of all workers.

Gamma Radiation

Estimates of gamma radiation exposure have been based on information from other operating uranium mines and calculations from first principles.

Table 14.26 provides a summary of the annual gamma doses from other open-cut uranium mines. Results show that generally, annual gamma doses are low and well within the internationally-accepted limit.

Table 14.26: Gamma doses to workers reported from other open-cut mines

Mine	Operation	Average (mSv/a)
Ranger	Underground	1.0
Rossing	Open pit	0.6
McLean Lake	Underground	0.5

Thompson and Wilson (1980) quote a theoretical gamma dose rate of 65 µSv/h per cent of uranium from an extended plan of exposed uranium ore. The figure provides an estimate of maximum gamma exposure without taking into account that most mine workers in the Wiluna Uranium Project would be equipment operators and, therefore, would be shielded by the mining equipment.

The average ore grade at Millipede is 550 mg/kg uranium, equal to 0.055% uranium. However, the average grade of all material mined (including overburden) is expected to be approximately 300 mg/kg (0.03% uranium). Average grades at Lake Maitland are expected to be very similar. For a full year (assume 2000 working hours per year), the theoretical maximum exposure would be approximately 3.9 mSv/a at both Millipede and Lake Maitland. As noted, this figure does not take into account the shielding provided by the mining equipment and based on gamma radiation levels observed in other open-cut uranium mines, it is estimated that miners would on average receive 1 mSv/a from gamma radiation.

Radionuclides in Dust

Estimation of exposures from the inhalation of radioactive dust can be based on predicted total suspended particulate airborne dust concentrations. The excavation of ore at Millipede is expected to generate relatively low levels of dust. The ore body generally lies below the water table and would be damp or wet when mined, with dust suppression used when necessary. During excavation of the resource test pit at Centipede in 2010, low levels of dusting were observed, confirming the initial predictions.

Estimates of dust concentration in the pit are based on assumed levels. For the purpose of this assessment, it has been assumed that total dust concentrations in the pit would be in the order of 1 mg/m^3 (Air Assessments, 2011). Similar ground and pit conditions exist at Lake Maitland.

Assuming all material mined at Millipede and Lake Maitland has an average grade of 300 mg/kg uranium, the calculated annual dose would be 0.3320 mSv/a (Toro, 2011a – Section 6.2).

It is expected this would be the maximum dose and average doses would be lower than this by a factor of two, due to the high moisture content of the material and dust control measures.

Radon Decay Product

RnDP doses to miners have been calculated by estimating the release rate of radon into the mine (in the shape of a pit) and calculating how often the air in the pit would change (known as the ‘ventilation rate’).

The release rate of radon has been calculated from the estimated emanation rates of radon. The ventilation rates have been determined using the model developed by Thompson (1994). This model shows that the ventilation rate for a pit is proportional to the wind speed on the surface.

The Millipede pit would be mainly producing ore in the first half of the life of the operation, with the Lake Maitland pit producing in the second half. The radon emanation from ore from both mines has been estimated to be 3.6 $Bq/m^2/s$ from areas of 159 ha and 206 ha, respectively, based on a pit depth of no more than 15 m.

For the purposes of this assessment, the doses have been estimated for the worst case, that is, at the point of maximum pit size. In this scenario, it is also assumed that all radon emanation would be from the pit floor and that the walls did not produce significant amounts of radon. This is a reasonable assumption as the surface area of the walls would be small compared to the surface area of the base of the pit (walls would be approximately 5% of the exposed surface area).

The baseline monitoring shows that during still night conditions, radon and RnDP concentrations would rise. Therefore, doses have been estimated for two exposure situations, as follows:

- Normal atmospheric conditions, where radon and RnDP are dispersed; and
- Stable atmospheric conditions, mainly at night, when there is minimal air movement.

The radon concentrations are calculated to be approximately 60 Bq/m^3 under normal ventilation conditions (Toro, 2011a – Section 6.2). Based on a conservative equilibrium factor of 0.5 (the ratio of RnDP concentration to radon concentration), this equates to an annual RnDP dose of 1.5 mSv/a for a miner working for a full year under normal ventilation conditions (assuming 2000 working hours per year).

To assess the doses during stable atmospheric conditions, the baseline monitoring has been used, which shows that the RnDP concentrations at night could be on average four times higher than the usual daytime RnDP concentrations. Therefore, using the same ratio and assuming this would apply with any additional Project originated radon, the annual dose for a miner working under constantly still ventilation conditions would be approximately 6 mSv/a.

The workforce would normally operate under a rotational shift arrangement, involving alternating day and night shifts. Under these arrangements, the estimated dose to a miner would be a combination of the still and normal ventilation conditions. The estimated RnDP dose would be approximately 3.8 mSv/a for a miner working both day shifts and night shifts.

Total Dose Estimates (Miners)

The total radiation dose to which a worker is exposed is the sum of exposure to gamma radiation, radiation associated with airborne dust and exposure to radon decay products. Table 14.27 provides a summary of the estimated doses to miners. In all cases, doses are well below the limit. In the case of the Wiluna Project, the estimated dose is just over a quarter of the limit.

Table 14.27: Miner total radiation dose estimates (averages)

Workers	Gamma Dose (mSv/a)	Dust Dose (mSv/a)	RnDP Dose (mSv/a)	Total Dose (mSv/a)	Limit-Standard (mSv/a)
Estimated average doses to miners at Millipede and Lake Maitland	1.0	0.32	3.8	5.1	20
Rossing pit worker (actual doses)	0.6	0.4	1.2	2.1	20
Ranger mine worker (actual doses)	0.5	0.3	0.1	<1.0	20

Processing Plant Workers

The processing plant would be located to the west of the Millipede deposit. Its operation, including radiation impacts from the plant, product packaging and transport, has already been assessed (EPA Assessment 1819 and EPBC 2009/5174). There will be no processing facility at Lake Maitland under this Proposal.

Ore would be stockpiled on a ROM pad and would be moved to the processing plant as required. In all, there may be up to 40 workers rotating on both day and night shifts. They would generally work over various parts of the plant and therefore be considered as one homogenous workgroup for the purposes of radiation dose assessment. Doses to workers in the uranium packaging and storage areas have been calculated separately.

Gamma Radiation

Estimates of gamma doses for processing plant workers are based on doses from uranium processing facilities elsewhere. Average gamma doses for plant workers at Olympic Dam (BHP Billiton, 2009) are 1 mSv/a to 2 mSv/a, with a maximum of 2 mSv/a. It is expected that doses in Toro's processing plant would be similar to these levels as exposure pathways are similar, as is the grade of the material in the plant and the conventional uranium concentrator circuit, used at both sites.

Radionuclides in Airborne Dust

Dust levels in the processing plant are expected to be low due to the process material being mainly wet or damp. Sources of dust would include dried spillage and transfers of raw materials. Operational controls would ensure that spillages were cleaned up promptly before they dried and had the potential to become a source of dust. Doses from airborne dust also would be low due to the relatively low grade of the material being processed. Where concentrated uranium-bearing material is present, such as in the uranium extraction and packing area, additional engineered dust controls would be employed.

Estimates of doses are based on the assumption that the predominant dust in the processing facility, due to the handling and processing of wet ore, would be ore dust and the average dust concentration is assumed to be 1 mg/m^3 (identical to the dust conditions in the mine). However, the dust in the plant is assumed to be at the processing ore grade of 800 ppm uranium. Using the method outlined in the mining section, the estimated average dust dose for plant workers is 0.64 mSv/a.

Dust generated from the haulage of ore from Lake Maitland to the central processing facility is expected to be minimal. Damp or wet ore would be loaded into haul trucks and the loads covered.

The Lake Maitland haul road would be constructed using local materials that contain no mineralisation. For this reason, there is no radiation risk associated with the haul road and the dust generated during its use. Along the haul road, water carts using dribble bar sprayers would be used to ensure the road remains damp and dust is kept to a minimum. Passive dust monitoring stations would be established along the length of the haul road from Lake Maitland to the processing plant to ensure that the operating systems to minimise dust were working. Where airborne dust levels were found to be higher than background levels, further controls would be put into place.

Radon Decay Products

RnDP doses to processing plant workers from Project-originated radon are expected to be low and a minor component of total dose. This is because the plant would be in the open and naturally ventilated. The radon contour plots produced from the air quality model show a Proposal-impact radon concentration of less than 5 Bq/m^3 at the site of the processing plant. Assuming an equilibrium factor of 0.2 between the radon concentration and the RnDP concentration, and assuming an exposure of 2000 working hours per year, the calculated occupational RnDP dose in the processing plant is 0.05 mSv/a.

Total Dose Estimates (Process Plant Workers)

The average estimated doses to processing plant workers is the sum of the gamma, RnDP and dust components and is calculated to be less than 4 mSv/a. This figure is well below the maximum worker exposure level of 20 mSv/a. Average annual doses reported from the Olympic Dam processing plant (BHP Billiton, 2009) are similarly low (Table 14.28).

Table 14.28: Process plant worker – total radiation dose

Processing Plant	Average Dose (mSv/a)
Olympic Dam (Concentrator)	1–2
Olympic Dam (Hydrometallurgical Plant)	1–2
Olympic Dam (Product Packers)	2

Workers in Product Packing Areas

The product packaging area was part of the assessed Wiluna Uranium Project (EPA Assessment 1819 and EPBC 2009/5174). There are no additional product packing facilities required to implement this Proposal.

There is potential for elevated exposure to gamma radiation and radionuclides from airborne dust in parts of the plant used for uranium concentrate packaging and storage. BHP Billiton (2009) reports that doses to full-time product packers since commencement of operations at its Olympic Dam Mine have remained low at less than 2 mSv/a. This is attributed to the specially designed enclosed ventilated uranium packing booth and also to the consistent use of personal protective apparel. Workers wear powered respiratory protection and disposable coveralls. Use of protective apparel and radiation hygiene procedures are strictly enforced through an integrated safety management system. These features, including management procedures, are now industry standard and would apply at the Wiluna Uranium Project processing plant.

The product packing facility would employ a high degree of automation and include radiation protection mechanisms such as control interlocks, dust extraction and scrubbing, and designs for ease of spillage clean up.

The estimated doses for product packing personnel are expected to be less than 2 mSv/a.

Transport Workers

The proposed transport route under this Proposal is the same as under the approved Wiluna Uranium Project (EPA Assessment 1819 and EPBC 2009/5174).

Product would be exported from Australia either through the Port of Adelaide or Darwin Port. Truck drivers transporting the product would be exposed to low levels of gamma radiation for the duration of the journey. Gamma radiation measurements in truck cabins transporting uranium oxide are reported in BHP Billiton (2009) as being on average 0.001 mSv/h. For a 36 hour trip between Wiluna and Port Adelaide, this equates to 0.036 mSv. A driver may make up to 12 of these trips per year, resulting in a total dose of approximately 0.5 mSv/a.

For routine mining operations, drivers would be employed to transport ore between the mining areas and the processing plant, and would be solely involved in this task and related roadwork maintenance. Doses to drivers are expected to be similar to, or less than, equipment operators in the mine, as the trucks would be fitted with air conditioned cabins.

Other Workgroups

The other key workgroups for which doses have been assessed are:

- Administration workers; and
- Construction workers.

Administration workers are expected to receive low exposures, because the office areas at Millipede and Lake Maitland would be located away from the mine and outside of the processing plant. Air quality modelling shows that at the office area, the RnDP concentration would be 0.003 $\mu J/m^3$ and radiation from radionuclides in airborne dust would be 0.01 mBq/m^3. Assuming dose conversion factors from ARPANSA (2005), this equates to an annual dose of less than 1 mSv.

14.7.5 Estimated Doses – Members of the Public

The Managing NORM Guidelines (DMP, 2010b) define a critical group for the purposes of radiation assessment as:

> 'a group of members of the public comprising individuals who are relatively homogeneous with regard to age, diet, who have behavioural characteristics that may affect the doses received and who are likely to receive the highest radiation doses from a particular operation.'

Toro has assessed the potential for members of the public outside the mine areas to be exposed to radiation as a result of emissions from Toro's operations. Exposures to members of the public have been determined by identifying potential critical groups of people who may be affected. The critical groups for the purposes of this analysis are:

- Residents of Wiluna;
- Residents or workers at the Millbillillie Pastoral Station, Ngangganawili Community and Bondini Reserve;
- People residing at Toro's accommodation village;
- Residents at the Barwidgee Pastoral Station; and
- Residents of Lake Way Pastoral Station.

Approach to Public Dose Assessment

The method for dose assessment for members of the public is identical to the method used for workers, as follows:

- The main potential radiation exposure pathways are identified;

- Estimates of exposure for each of the pathways are made (based on monitoring data or modelled data);
- Standard dose conversion factors are used to determine a dose for each of the pathways; and
- The doses from each pathway are summed to produce a total expected dose.

Doses to the critical groups are based on the estimated concentrations at the critical group locations, combined with the occupancy time (the amount of time people spend at the particular location), and the appropriate age. Dependent dose conversion factors are as supplied in ICRP Publication 72 (ICRP, 1996).

The important exposure pathways for members of the public are:

- Inhalation of radioactive dust; and
- Inhalation of the decay products of radon.

Exposure from gamma radiation is not considered to be significant, because the main sources of gamma radiation would be stockpiles and tailings, which would be inaccessible to the public and within the mine lease areas. Gamma levels at the closest publicly-accessible location would not be distinguishable from the current natural background radiation.

Groundwater from the vicinity of the ore bodies is saline and unsuitable for human consumption. Therefore, there would be no exposure from this source. The water supply for Wiluna is from groundwater, but this source is 25 km to the north-west of the ore body and would not be affected by operations at the mine, because there is no hydraulic connection between the two.

The main exposure pathways are from emissions to air. The exposure to airborne emissions is estimated using results from air quality modelling (Crouch, 2012 – Appendix 10.51). To determine the radiological impact, it is necessary to convert the mass concentration (mg/m^3) of airborne radionuclides into activity concentration (Bq/m^3). This is done by determining the amount of radioactivity per gram of material using an assumed specific activity (of uranium). It is therefore assumed that the dust concentration contours are directly proportional to activity concentration contours.

The average ore grade for the whole of mining is approximately 800 mg/kg. However, the dust dispersion modelling also includes dust from sources other than ore, e.g. road dust and dust from overburden removal. For the purposes of radiological assessment of public exposures, an average uranium in dust concentration of 200 mg/kg was used (for all dust emissions).

Radiation Exposure: Critical Group Exposure to Airborne Radionuclides

The predicted total radiation doses to the key critical groups are summarised in Table 14.29.

Inhalation doses from RnDP and radionuclides in dust have been determined by assuming that residents at the critical group locations are exposed for a full year (8760 h) to the modelled RnDP and radionuclides in dust concentrations at these locations.

Doses to members of the public are not expected to exceed 1/20 of the acceptable limit as shown in Table 14.29.

Table 14.29: Predicted dose to Critical Groups from inhalation

Key Receptor Locations	Dose From Pathway (mSv/a) (for Highest Year of Emissions)			
	Inhalation of RnDP	Inhalation of Radionuclides in Dust	Gamma Radiation	Total Dose
Wiluna Township	0.020	0.002	0	0.022
Bondini Reserve	0.014	0.001	0	0.015
Ngangganawili Community	0.031	0.003	0	0.034
Millbillillie Station	0.020	0.001	0	0.021
Lake Way Station	0.005	0.000	0	0.005
Apex Village (care and maintenance)	0.042	0.005	0	0.047
Toro Energy Construction Camp	0.031	0.002	0	0.033
Toro Energy Operations Camp	0.015	0.001	0	0.016
Barwidgee Station	<0.005	0.000	0	0.005

Note that member of public dose is limited at 1 mSv/a.

14.7.6 Non-human Biota

When conducting an assessment of radiological impacts to non-human biota, it is a standard practice to utilise the ERICA software tool. This method has been endorsed for use in Australia by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA 2010). The assessment for mining at Lake Way and Centipede was conducted using the ERICA software at a tier 1 level of assessment (Toro Energy 2011a – Section 6.2.8).

The ERICA software uses media concentration and species concentration ratios to determine the relative radiological risk to a set of reference animals and plants. The media concentration is a measure of the increase in radionuclide concentrations in the media that the plants and animals are associated with and can be soils or water. In the following ERICA assessment for the Extension to the Wiluna Project (Toro Energy 2015 – Appendix 10.34), the media used is soils as there is no permanent standing surface water in the region. The Project originated media concentration can be calculated from the results of atmospheric dispersion modelling.

For concentration ratios, the ERICA software accesses a standard set of databases to determine radionuclide uptake by various species. This then provides a quantitative measure of radiological impact. Previously there has been some concern that the databases are based on northern hemisphere species. It is important to note, however, that the ERICA assessment is based on types of species rather than specific species. ARPANSA (2010) notes that where specific species information becomes available, then it should be utilised. To this end, ARPANSA has recently released a publication which provides information on concentration ratios for a limited number of Australian species (ARPANSA 2014).

An ERICA assessment is carried out at one of three tiers where the level of assessment depends upon the impacts (ie; the higher the assessed impacts the higher the level of scrutiny) (ARPANSA 2010). Tier one is the simplest assessment level, requiring the minimum input data, and provided the assessment results meet predefined screening limits, negates the requirement for further assessment. Further tiered assessments occur when the potential impacts are higher. (For example, exceeding a trigger level using a Tier 1 assessment requires Tier 2 assessment for which additional data and information are needed on the particular exposure situations). Tier 2 assessments are also conducted when additional data is available to give a better indication of the potential impacts. The overall system is designed to ensure that an appropriate level of information is obtained and used to undertake the assessment and that the assessment is commensurate with the potential risk.

The assessment is based on a screening level which is defined as the calculated radiation dose rate below which no effects would be observed and the ERICA default level is set at 10 µGy/h (ARPANSA 2010).

The ERICA software tool calculates the assessment results as a 'dose rate' to the different species. A 'Risk Quotient' is also calculated which is the ratio of the dose rate to the screening dose rate. Risk quotients are presented both for the 'expected value' and for the 'conservative value'. The default conservative value is three times higher than the expected value and represents the value at which there is only a 5% chance that the calculated dose rate exceeds the screening level. This represents a significant level of conservatism.

The ARPANSA data (ARPANSA 2014) provides some concentration ratio information for Australian species and in this assessment, these values have been used to determine impacts to kangaroos.

The latest version of the ERICA software was released in November 2014.

The main pathway of significance in this assessment is the aerial dispersion of Project generated dust that contains radionuclides.

Atmospheric dispersion modelling has been conducted for the extended Project based on new emission sources. The dust deposition contours have been determined (Air Assessments, 2014) and are shown in Figure 14.11 and Figure 14.12.

The modelling did not include dust generated from ore haulage between Lake Maitland and the processing plant. This is because the haulage road would be constructed with non-mineralised materials. In addition, transported ore is expected to be damp from mining, with all loads covered to prevent loss of materials. Therefore, it is expected that there would be no routine release of ore dust.

The dust deposition as a result of operations would result in an increase in soil radionuclide concentrations. The radionuclide concentrations can be calculated from the dust deposition figures. The assessment has been conducted at the 0.5g/m^2/month contour for the Centipede/Millipede area (Figure 14.11) and at the 1g/m^2/month contour for the Lake Maitland area (Figure 14.12).

Figure 14.11: Combined dust deposition from mining and processing rate at Millipede and Centipede (g/m^2/month)

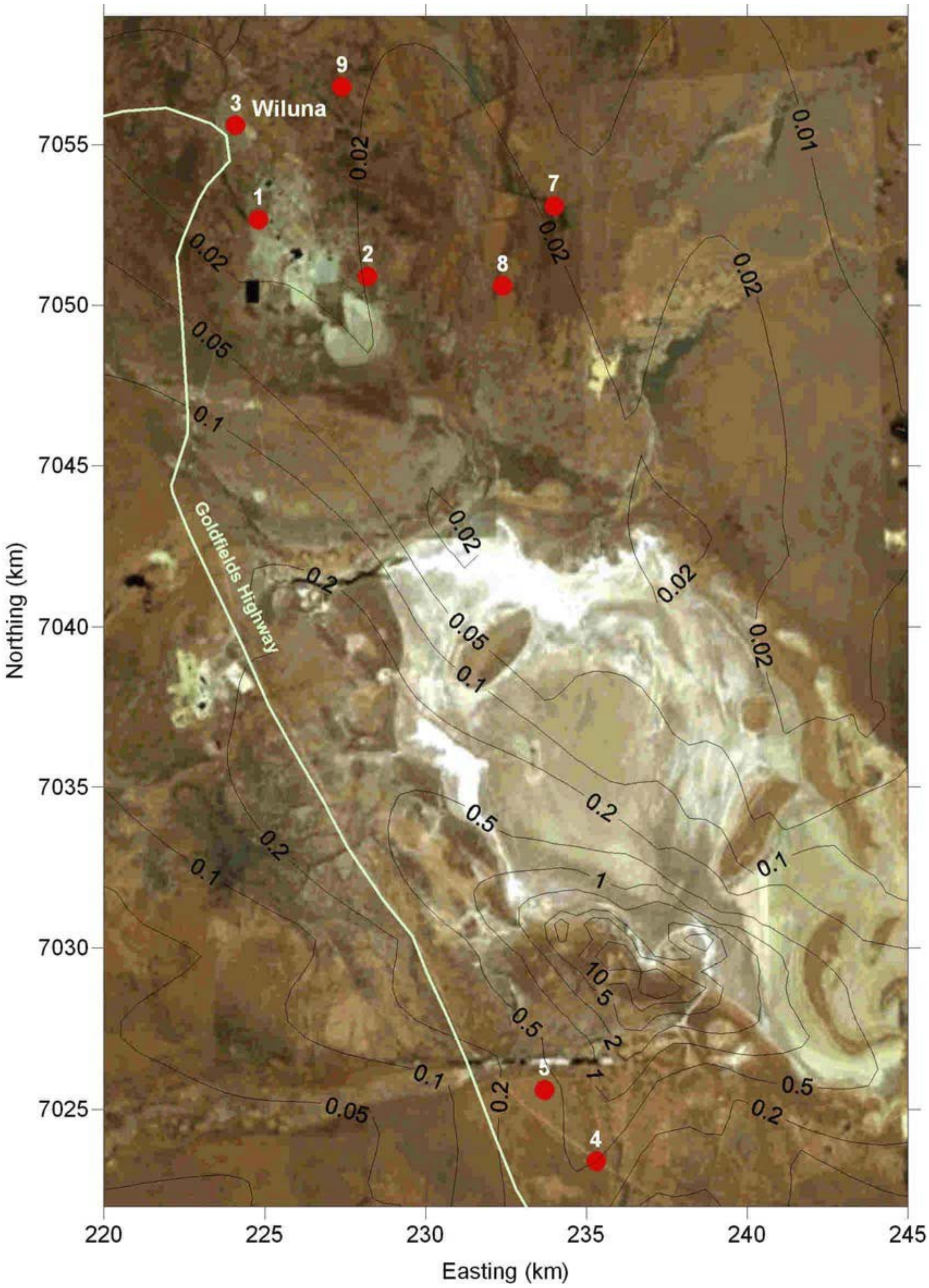
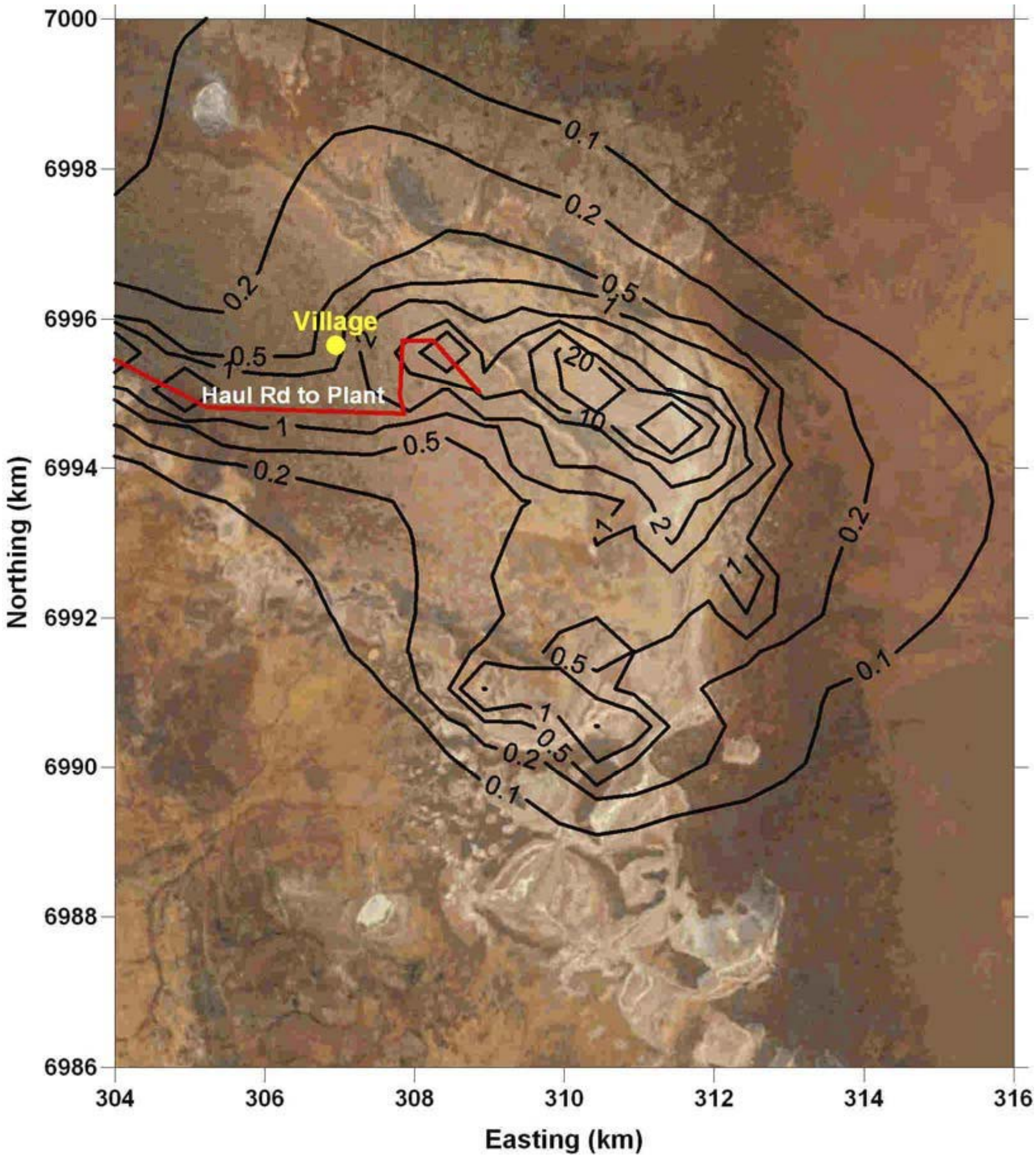


Figure 14.12: Dust deposition from mining at Lake Maitland ($g/m^2/month$)



The radionuclide content of the deposited dust can be determined by considering the uranium content of the dust as follows: it is assumed that the average ore grade is 500ppm of uranium and that 50% of the dust generated is ore and 50% is inert cover material. This gives an average uranium grade of 250ppm in all dust emitted. The uranium (as U238) activity concentration in material containing 250ppm of uranium is approximately 3Bq/g. If it is assumed that the decay products of U238 are in secular equilibrium, then the activity of the decay products in the material are also approximately 3Bq/g.

The change in radionuclide concentration is calculated as follows:

- Centipede/Millipede Area

- Dust expected to be deposited for 18 years (216 months) at a rate of 0.5 g/m^2/month giving 108 g/m^2
- The dust is expected to mix in a mixing volume of soil that is 10 mm deep (Kaste *et al,* 2007) (which is equivalent to a volume of 0.01 m^3)
- The soil density is estimated to be 1.5 t/m^3, giving a soil mass of 15 kg in the mixing volume
- Therefore there is 108 g of Project dust mixed into 15 kg of natural soil, after 18 years of operations
- As noted, there is approximately 3 Bq/g of U238 and its decay products, which means that there is 324 Bq of U238 mixing into 15 kg, giving an increase in soil concentration of approximately 22 Bq/kg. (Note that the regional average is 41 Bq/kg, with a range of 24 to 110 Bq/kg).

- Lake Maitland

- Dust expected to be deposited for 6 years (72 months) at a rate of 1 g/m^2/month giving 72 g/m^2
- Using the same methodology as for Centipede and Millipede, the increase in soil concentration is approximately 14 Bq/kg.

The ERICA software uses a standard set of concentration ratios. For this assessment, the default ERICA values have been used.

A user defined species was added, being a kangaroo and the concentration ratio values used are shown in Table 14.30 and are taken from ARPANSA (2014).

Table 14.30: Concentration Ratios for Kangaroo

Organism	Source	Concentration Ratio (Bq/kg(fresh weight) per Bq/kg(soil))[1]				
		U^{238}	Th^{230}	Ra^{226}	Pb^{210}	Po^{210}
Kangaroo	ARPANSA 2014– maximum of reported arithmetic means	**0.007**	no data	**0.041**	**0.02**	**0.55**

Note 1 – Where there is no data, the default ERICA values will be used.

A Tier 2 ERICA assessment was conducted for the full set of reference animals and plants in the ERICA system and a user defined species of kangaroo. The ERICA software requires a geometrical model of the user defined species to be entered and the following parameters were used;

- Kangaroo; mass 50kg, height 1.5m, width 0.75m and depth 0.75m.

ERICA assessments were conducted using a soil radionuclide concentration of 22 Bq/kg (for each long lived uranium-238 series radionuclide) for the combined Centipede and Millipede operation and 14 Bq/kg (for each long lived uranium-238 series radionuclide) for the Lake Maitland operation. The resulting risk quotients are shown in Table 14.31 and Table 14.32, where the risk quotient is the ratio of the derived dose rate to the screening level. When the risk quotient is less than 1, no additional assessment is required.

Table 14.31: Tier 2 ERICA Assessment – Centipede-Millipede

Organism	Concentration Ratio source	Risk Quotient (expected value)	Risk Quotient (conservative value)
Lichen & bryophytes	ERICA default	0.52	1.56
Arthropod - Detritivorous	ERICA default	0.02	0.05
Flying insect	ERICA default	0.02	0.05
Grasses & herbs	ERICA default	0.10	0.29
Mollusc – Gastropod	ERICA default	0.02	0.06
Shrub	ERICA default	0.13	0.40
Bird	ERICA default	0.01	0.04
Amphibian	ERICA default	0.02	0.07
Reptile	ERICA default	0.02	0.07
Kangaroo	ARPANSA 2014	0.05	0.15
Tree	ERICA default	0.01	0.03
Mammal (small burrowing)	ERICA default	0.02	0.07
Mammal (large)	ERICA default	0.02	0.06

The assessment identified lichen and bryophytes species would exceed the screening level of 10µGy/h using the conservative values.

As noted previously (Toro Energy 2011a), lichen and bryophytes do not have a well-developed root system, and derive most of their nutrients from the atmosphere and therefore would be expected to be affected by dust deposition. However, they are extremely radio resistant with a threshold no effect dose rate of approximately 125,000 uGy/h (UNSCEAR 1996).

Table 14.32: Tier 2 ERICA Assessment – Lake Maitland

Organism	Concentration Ratio source	Risk Quotient (expected value)	Risk Quotient (conservative value)
Lichen & bryophytes	ERICA default	0.33	0.99
Arthropod - Detritivorous	ERICA default	0.01	0.03
Flying insect	ERICA default	0.01	0.03
Grasses & herbs	ERICA default	0.06	0.19
Mollusc - Gastropod	ERICA default	0.01	0.04
Shrub	ERICA default	0.08	0.25
Bird	ERICA default	0.01	0.02
Amphibian	ERICA default	0.01	0.04
Reptile	ERICA default	0.02	0.05

Organism	Concentration Ratio source	Risk Quotient (expected value)	Risk Quotient (conservative value)
Kangaroo	ARPANSA 2014	0.03	0.10
Tree	ERICA default	0.01	0.02
Mammal (small burrowing)	ERICA default	0.01	0.04
Mammal (large)	ERICA default	0.01	0.04

No species exceeded the screening level of 10µGy/h for the Lake Maitland operations area.

Conclusion

The ERICA Tier 2 assessment has indicated that no species of flora or fauna, apart from lichen and bryophytes, exceeded the screening level of 10uGy/h.

After taking into account the published literature on the radio resistance of lichen and bryophytes, the risk of radiological harm was assessed as 'negligible' for each assessed species, including kangaroo (Toro Energy, 2015 – Appendix 10.34).

14.7.7 Bush Tucker Survey

As discussed in Section 9, surveys were undertaken with Traditional Owners to identify plant species used for bush tucker and medicinal purposes at both Millipede and Lake Maitland. The risk from consumption of locally sourced foods as a potential radiation pathway has been assessed as negligible.

14.7.8 Radionuclides in Fauna and Vegetation

Toro undertook an assessment of the potential doses from the consumption of foodstuffs grown close to the Project area at Millipede (Toro Energy, 2011c – Section 6.2 – Appendix 10.59). The assessment was based on airborne emissions from the operations after 15 years of deposition, mixing with soils and being taken up by plants and animals which may be consumed by humans.

Rather than model a hypothetical distribution of edible vegetation at the Project boundary, the most restrictive uptake factors for vegetation types for the long-lived radionuclides in the U^{238} decay chain were applied (IAEA, 1992). Based on the modelled dust deposition levels at the Project boundary and a soil mixing depth of 10 cm, it is calculated that by the end of operations at Millipede, the radionuclides in soils at the boundary would increase over the existing levels by the amounts shown in Table 14.33.

Table 14.33: Predicted increase in soil radionuclides outside operational area at Millipede

Radionuclide	$U^{238/234}$	Th^{230}	Ra^{226}	Pb^{210}	Po^{210}
% increase in concentration	5	8	4	3	3

The results in Table 14.33 show the relative increase over the average naturally occurring radionuclides in soil in the broader region as a result of dust deposition from the operation (but not including soil samples from on top of the ore deposit).

It could be expected that vegetation growing in this soil would take up the deposited radionuclides in addition to the existing radionuclides in soil. If it is assumed that the increase in uptake is proportional to the increase in soil radionuclide concentrations, then the radionuclides in vegetation would similarly increase by approximately 5% (8% in the case of Th^{230}).

If a person consumed 200 kg of vegetation from the immediate Project boundary after 15 years of dust deposition, then it can be predicted that they could receive a dose of up to 1 mSv as a result of the operation.

At Lake Maitland, a human health and ecological risk assessment was undertaken to estimate the potential impact of radiological releases on specified receptors (Golder Associates, 2011f – Appendix 10.60). As part of the assessment, consultation was undertaken with Traditional Owners to better understand the consumption of wild game in the area.

The discussions with Traditional Owners indicated the area is infrequently used due to its remote location and abundance of bush tucker in more accessible regions. However, it was assumed that Traditional Owners would spend a maximum of four weeks a year, seven days per week for up to 24 hours per day visiting the Project area (i.e. adults camping, hunting and collecting bush tucker with younger people alongside the elders). During that period, it was estimated that 100% of vegetation and meat would be consumed from the immediate vicinity.

The assessment also considered occupants of the homestead on the Barwidgee pastoral lease, assuming their presence for 48 weeks a year, seven days a week and 24 hours per day. They are unlikely to hunt for food and consume fruit or meat from or surrounding the Project area. Occupants of the Toro accommodation village to support mining at Lake Maitland would have the same exposure.

The radiological dose estimates for the human receptors were below the regulatory incremental dose limit of 1 mSv/a. The results of this risk assessment indicated that any incremental effects from implementation of the Proposal at Lake Maitland would be insignificant.

14.8 Impact Management

The creation of airborne dust and changes in local radionuclides cannot be avoided completely in a uranium mining operation. Toro has therefore planned the location of its infrastructure and designed the rest of the Project so that the impacts are minimised and can be managed to protect human health.

The main source of dust from the Project is the already assessed (EPA 1819 and EPBC 2009/5174) processing plant. Even though the Lake Maitland deposit is located 95 km from the Millipede and Centipede deposits, Toro is proposing a single, central processing facility. This would allow the generation of processing dusts to be geographically restricted and facilitate precise monitoring. All ore would be hauled to the processing plant in covered vehicles along roads kept damp to control dust.

Baseline dust monitoring continues to be undertaken (including along the haul road). Toro is developing a picture to enable rehabilitation and decommissioning of the Project to return the region, as much as practicable, to pre-mining conditions. The baseline information will serve as the benchmark for rehabilitation and decommissioning planning.

As further discussed in Section 16, the tailings created during the operation have the potential to contaminate local groundwaters. Toro has proposed to store all tailings in mined-out voids at Millipede and Centipede to contain their presence in the region. Following mining at Lake Maitland and also at Lake Way, pit voids would be free of most of the uranium that was in situ and backfilled with waste material. This would lower the regional background radiation and remove pathways for uranium and radionuclides to naturally enter the environment. Achievement of these outcomes would be assessed as part of operational monitoring.

The TSF would be located on the edge of the salt lake at Lake Way. Toro has undertaken modelling of how groundwater and tailings would interact over time. Under a worst case scenario, it was found that seepage from the TSF would cause an initial spike in groundwater uranium levels, but over time these levels would reduce to baseline values. Toro has committed to further modelling prior to the submission of its Mining Proposal to provide further comprehensive information on groundwater and tailings behaviour.

Another reason for the TSF location proposed is to make use of the reduced sediments present at Lake Way. It has been observed that these sediments act as a form of chemical trap, capturing leachates and immobilising them. Toro's further modelling is expected to demonstrate that this is what is happening in the natural system and therefore supports the conclusion that the TSF has been located in the most appropriate place.

The TSF would be a permanent structure and has been designed to perform accordingly. Toro has undertaken studies into the closure of the TSF and how this would prevent fauna and plant root ingress and water egress.

Prior to implementation of the Proposal, Toro intends to complete a full Definitive Feasibility Study in which the final design and sizing of all infrastructure would be presented in detail. During this study, dust control will be examined in further detail. Engineering will look at methods to reduce dust generated from hauling and processing ore—the two most likely sources of Project dust. This will include the use of sprays on stockpiles and around ventilation points at the plant. Water carts with dribble bars would be used along ore haul roads to immobilise any mineralised dust that might be generated from nearby mining activities. The results of these engineering studies will also inform the completion of a Mining Proposal for the Project to be submitted to the DMP which will include all dust management design measures.

Toro would have an approved Radiation Management Plan (RMP) and a Radioactive Waste Management Plan (RWMP) in place prior to the commencement of construction and subsequent mining operations. The RMP (Appendix 6) and RWMP (Appendix 7) would be reviewed before the Proposal commenced the construction phase and periodically after that.

All details of worker exposure would be recorded and made available for assessment in compliance with government requirements. Toro would report on its radiation management in its annual environment report.

Any incidents, as defined in the RMP, would be reported to the DMP and the Radiological Council and included in the annual report. Any anomalous exposure results would also be investigated and, should the investigation conclude that the results were accurate, these would also be reported to the DMP and the Radiological Council and included in the annual report.

To support the findings of the ERICA assessment, Toro would undertake periodic sampling for radionuclides in non-human biota. These results would be reported on in the annual report. Where bio-accumulation of radionuclides was higher than expected, Toro would investigate these findings and report on them accordingly.

14.9 Commitments

Toro's commitment to a range of management and operational measures to maintain radiation doses As Low as Reasonably Achievable would ensure that any dose arising from implementation of the Proposal would be well within the limit.

Toro would undertake regular monitoring of radionuclides in dust and soils. The timing and frequency of this sampling would be included in the company's RMP.

Should mining be approved, Toro would maintain bush tucker surveys:

- Within the ore body;
- Upwind of prevailing winds; and
- In regional locations (e.g. Barwidgee Station).

The timing of surveys would take into account the availability of the fruits, nuts and seeds of bush tucker.

Monitoring sites would be established downwind of the prevailing wind direction and at various distances from operations with soil samples collected from each site.

Biannual monitoring would be undertaken in autumn and spring to capture varying wind directions, and to account for the various flowering and seeding times of these rain-responsive plants.

14.10 Outcome

Based on its management measures and commitments, and with an approved RMP in place, Toro concludes that the Proposal would have no adverse impacts on human health or on the health of non-human biota.

15 HERITAGE

15.1 Objective

To ensure that historical and cultural associations, and natural heritage, are not adversely affected.

15.2 Relevant Legislation and Policy

Both state and federal legislation apply to the protection of Aboriginal heritage, including:

- *Aboriginal Heritage Act 1972* (WA);
- *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* (Cwlth); and
- *Native Title Act 1993* (Cwlth).

The following policy documents are also relevant to the protection of Aboriginal heritage:

- EPA, 2004. Guidance Statement No. 41 *Assessment of Aboriginal Heritage*;
- Department of Aboriginal Affairs and Department of Premier and Cabinet, 2013. *Aboriginal Heritage Due Diligence Guidelines*, Version 3.0, 20 April 2013;
- Department of Aboriginal Affairs (DAA) guidelines regarding section 18 and risk assessment; and
- Australia ICOMOS, 2000. *The Burra Charter: The Australia ICOMOS Charter for Places of Cultural Significance 1999*.

The *Aboriginal Heritage Act 1972* provides protection for all places and objects in Western Australia that are important to the Indigenous people of Australia. Proponents are required to apply for clearance from the Minister for Aboriginal Affairs under section 18 of the Act if project implementation cannot avoid disturbance to an Aboriginal heritage site. A report or an Aboriginal heritage survey relevant to the site is also required to be submitted to the Aboriginal Cultural Material Committee which advises the Minister.

EPA Guidance Statement No. 41 provides guidance for the assessment of Aboriginal heritage as part of environmental impact assessments. The statement considers Aboriginal heritage as a relevant environmental factor

> 'in circumstances where the heritage values are linked directly to the physical and biological attributes of the environment, and when the protection and management of those attributes are threatened as a result of a proposed development.'

The statement indicates that a proponent should demonstrate that the relevant Aboriginal heritage issues have been identified and the proponent has considered how to minimise any adverse impact by the proposal on heritage values. It provides a list of actions to be considered, including undertaking an Aboriginal heritage survey.

Any non-Indigenous heritage sites found in and around Millipede and Lake Maitland fall under the jurisdiction of both the *Australian Heritage Council Act 2003* (Cwlth) and the *Heritage Act of Western Australia 1990* (WA). The purpose of these Acts is to protect important historic landmarks through identification, education, and preservation.

15.3 Proponent Studies and Investigations

A desktop review was undertaken to determine if any non-Indigenous heritage sites were located in the vicinity of either Millipede or Lake Maitland. The assessment included a review of any sites on the Site Register of Heritage Places. The State Register lists all heritage sites registered on local government heritage inventories, the Commonwealth Heritage List and the List of Classified Places managed by the National Trust of Australia (WA).

15.3.1 Millipede

Toro has reviewed available information about Aboriginal cultural heritage. This included a search of the Aboriginal Heritage Inquiry System (AHIS) held at the DAA to identify all Aboriginal heritage found or subject to investigation in the Wiluna region. Exploration and mining in the region since the early 1970s has significantly increased the recording of Aboriginal heritage. Toro's review of available information showed that between 1975 and 2011, at least 59 surveys had been conducted to investigate Aboriginal cultural heritage in the Wiluna region. The Cultural Heritage Management Plan (Appendix 8) lists heritage surveys in the region.

The purpose of Toro's review was to develop an understanding of Aboriginal cultural heritage in the region, identify Aboriginal people who may hold cultural knowledge relevant to the Proposal and to consider how this previous work could be built upon through further investigation.

As a result, further survey work has been undertaken relevant to proposed mining at Millipede:

- *Report of an Ethnographic Work Area Clearance Survey for the Dawson Hinkler and Millipede Project Areas* prepared for CDNTS by David Raftery, October 2011;
- *Report of an Archaeological Work Program Clearance Survey at Toro Energy Limited's Lake Way Project Area and an Ethnographic Work Area Clearance Survey at Toro Energy Limited's Millipede Project Area* prepared for CDNTS by Emlyn Collins and Jeremy Maling, December 2012; and
- *Report of an Archaeological Work Area Program Clearance Survey within Toro Energy Limited M53/1095* prepared for CDNTS by Emlyn Collins, March 2013.

These surveys were arranged by CDNTS, the representative body for the Wiluna Native Title Holders. In addition to the existing recorded cultural heritage sites and places, Toro has provided funds to CDNTS to undertake cultural mapping in consultation with Traditional Owners to allow the preparation of detailed management strategies for protecting identified Aboriginal objects or places of cultural significance.

Ethnographic cultural mapping has been undertaken of the entire area in which mining would occur at Millipede and also at Centipede and Lake Way. Archaeological cultural mapping is underway. A mining agreement is being negotiated with the Wiluna Native Title Holders.

15.3.2 Lake Maitland

Table 15.1 lists heritage surveys undertaken within or in the vicinity of the proposed mining area at Lake Maitland and are provided in the Cultural Heritage Management Plan.

Subsequent cultural heritage and archaeological surveys have been undertaken of the mining area as follows:

- Ethnographic Survey of Mega Uranium Lake Maitland Project Tenements conducted by CDNTS, July 2009;
- Archaeological work program clearance surveys of the Lake Maitland Uranium Project area undertaken by Robin Stevens, November 2009; February 2010; and
- Heritage Survey of the proposed Mega Redport Pty Ltd exploration program at the Lake Maitland Uranium Project east of Leinster, advice prepared by Stuart Fisher and Joe Dortch, August 2010.

In addition to these heritage surveys, an extensive report on the ethnographic background and Aboriginal territorial affiliations at Lake Maitland was prepared for Mega: *Report on the Aboriginal Ethnographic Background and Aboriginal Territorial Affiliations of the Lake Maitland Region in the North Western Goldfields in Western Australia for Mega Uranium Limited*, May 2009, by Daniel de Gand, Anthropologist, de Gand Pty Ltd.

Table 15.1: Heritage surveys in the region

Title	Author	Year
Report of a survey for Aboriginal sites at the Barwidgee Project	K Macintyre, B Dobson, C J Mattner and G Quartermaine	1993
Report of an Ethnographic Survey for Aboriginal sites at the Jundee Project, Barwidgee South and Barwidgee North	Macintyre, Dobson and Associates Pty Ltd	1993
Report of an Aboriginal Heritage Survey of South Lake Way Borefield, Mt Keith, Western Australia	C Prince, D Lantzke and S Campbell-Smith	1994
Report on an Ethnographic and Archaeological survey for Aboriginal sites at the Mandilla Well Project area on mining leases ML 37/654 and ML 37/655, Yandal Station north of Leinster, Western Australia	Macintyre, Dobson and Associates Pty Ltd	1996
Report of an Ethnographic and Archaeological Survey at Mount Joel, north of Bronzewing	Macintyre, Dobson and Associates Pty Ltd and J Harris	1997
Aboriginal Heritage survey – Lake Way and Barwidgee areas	R Chown and Dr B Machin	2001
An Ethnographic Survey of Aboriginal heritage sites within Lake Way and Barwidgee areas (Lake Way North, Little Diorite Well and Shady Well survey areas)	G H Pitt	2001
An Ethnographic Survey of Aboriginal heritage sites within Lake Way and Barwidgee areas (Mandilla Well North and East Honeymoon Well survey areas)	G H Pitt	2002

15.4 Existing Environment

15.4.1 Indigenous Heritage

Wiluna occupies an important position in Aboriginal culture in the Western Desert region, with Wiluna People retaining a strong commitment to traditional religious belief and ritual. It is traditionally a major Law centre and plays a central role at Law time with people travelling from as far away as Docker River (Northern Territory) to conduct rituals in and around Wiluna (Sackett, 1977).

Lake Way, as a large landmark, has sites which are significant to the original local groups.

In July 2013, the Federal Court of Australia determined that the Wiluna People hold Native Title over land that includes the Millipede mining tenements and a portion of the ore haul road alignment to link Lake Maitland to the processing plant (FCA, 2013). In doing so, the court accepted submissions on behalf of the Wiluna People that they have ‘rights and responsibilities to the land in accordance with Western Desert law and custom.’

Figure 15.1 is based on information from the AHIS showing registered sites and other heritage places within or in close proximity to proposed mining and infrastructure areas at Millipede and also at the already approved Centipede and Lake Way mining areas (EPA Assessment 1819 and EPBC 2009/5174). Table 15.2 provides further information about the status of those sites and places.

Figure 15.1: Heritage sites and places in the Millipede, Centipede, Lake Way mining areas

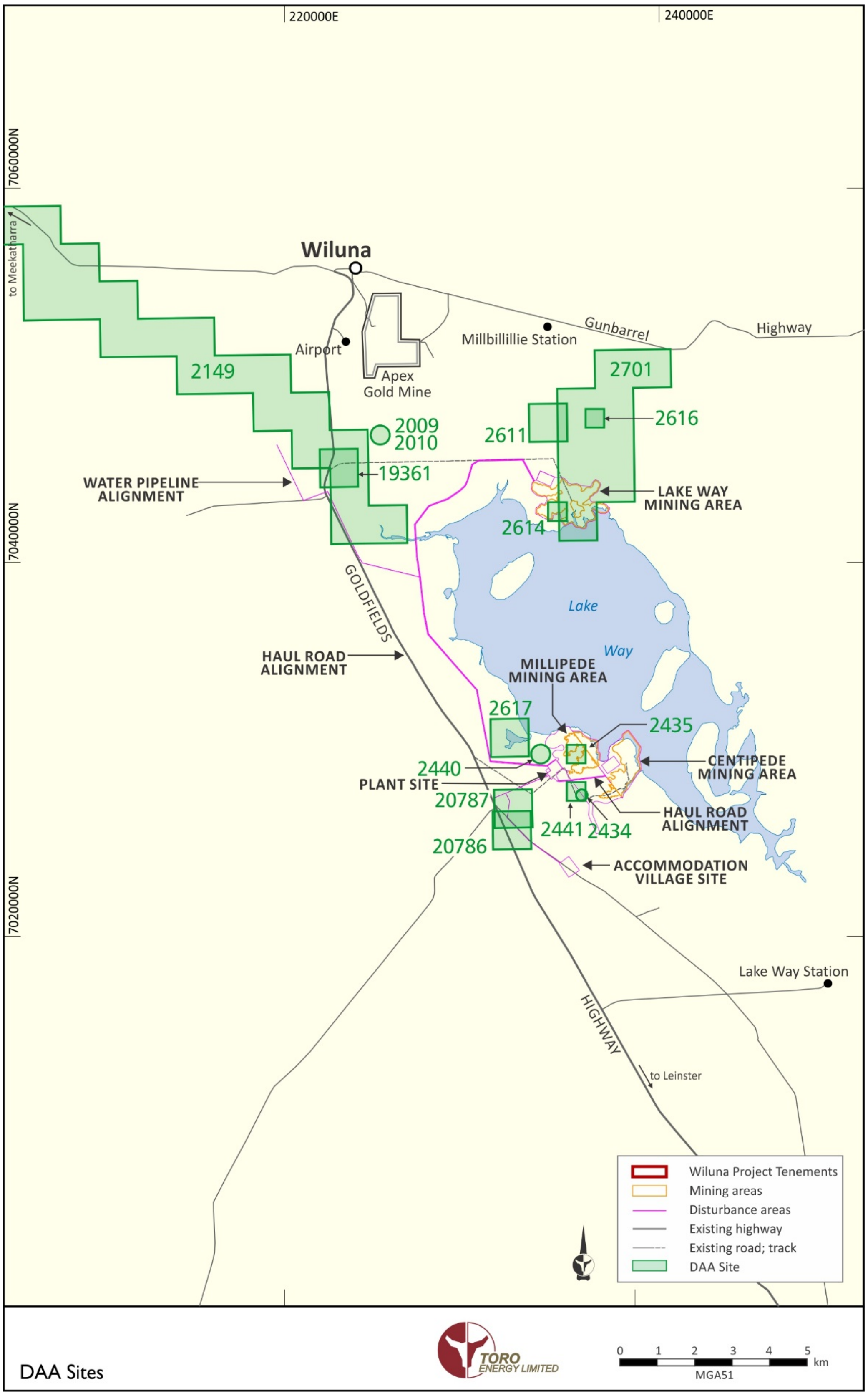


Table 15.2: Status of sites and places within Millipede, Centipede, Lake Way mining areas

ID	Status	Site Name	Site Type
2009	P	Wiluna South 1	Artefacts/scatter
2010	P	Wiluna South 2	Artefacts/scatter
2149	L	Tjilla	Mythological
19361	L	Butchers Well	Ceremonial/mythological
2611	L	Uramurdah Claypan	Mythological artefacts/scatter
2614	L	Area D	Artefacts/scatter
2616	L	Contemporary Artefacts	Artefacts/scatter
2701	P	Yuruwari	Ceremonial, mythological
2440	P	Lake Way 5	Artefacts/scatter
2441	L	Lake Way 6	Artefacts/scatter
2617	L	Yapukarumpi	Mythological
20786	S	Tel/01 Abercromby Creek	Mythological
20787	S	Tel/02 Abercromby Creek	Mythological
2434	S	Lake Way Find 1	Artefacts/scatter
2435	S	Lake Way Find 2	Artefacts/scatter

Source: AHIS, DAA.
Notes: S – Stored data (location has been determined not to be an Aboriginal site); L – Lodged (an application to determine whether an Aboriginal site occurs); P – Permanent register (location has been evaluated as an Aboriginal site).

Mining at Millipede and the establishment of infrastructure to support mining would occur in the vicinity of the following heritage places: Lake Way Find 1, (ID 2434), Lake Way Find 2 (ID 2435) and Lake Way 6 (ID 2441). The Aboriginal Cultural Material Committee has determined that Lake Way Find 1 and Lake Way Find 2 are not heritage sites. Lake Way Find 1 comprises two stone artefacts and Lake Way Find 2 has one stone artefact. Regionally, individual isolated stone artefacts are common and in certain environments they are ubiquitous. These latter conditions are likely to be found along creek beds and floodplains in the vicinity of Lake Way. The material used (quartz and chert) is typical and not exotic in the region.

Lake Way 6 comprises stone artefacts distributed over an area measuring 140 m x 70 m comprising mostly quartz. The AHIS records that there is insufficient spatial information to accurately determine the location of the site.

Primary and secondary ethnographic and archaeological evidence indicates that Lake Maitland is within the ancestral areas of the Tjupan people. The majority of Tjupan people now live in Leonora, Kalgoorlie, Wiluna and Meekatharra.

Despite this shift, there is a generation of Tjupan who have an active memory of semi-traditional life at and in the vicinity of Lake Maitland.

A search of the AHIS database shows there are no registered sites and no other heritage places recorded in areas where mining would occur and infrastructure established at Lake Maitland.

There is a scattering of heritage places to the north-west, south-west, north and east of the mining lease (between 3 km and 15 km from the mining area), while the most recent heritage survey work identified one place of cultural heritage significance, a smaller location and some artefacts (Table 15.3).

Table 15.3: Heritage places in vicinity of Lake Maitland

ID	Status	Site Name	Site Type
2091	L	Barwidgee Station North	Skeletal material/burial
2860	L	Red Hill	Man-made structure
19306	L	Walawurru	Ceremonial/mythological
24114	L	Mundu-Mount Joel	Mythological
24115	L	Mount Joel Soak	Mythological
24116	L	Walla-White Lake	Mythological
24117	L	Ullarri Hill	Mythological
24118	L	Mindi Hill	Ceremonial/mythological
24119	L	Warlawuru Djinna	Artefacts scatter/mythological
24120	L	Warlwuru Gunna	Mythological

Source: AHIS, DAA.
Notes: L – Lodged (an application to determine whether an Aboriginal site occurs).

15.4.2 Non-Indigenous Heritage

Early settlements were scarce in the arid environment beyond the Wiluna Township. There are two sites of European heritage significance remaining within the general locality of this Proposal.

The Mine Manager's House was built 2 km south-east of Wiluna in 1929. It was permanently entered on the Western Australian Register of Places 2002 (Heritage Council of Western Australia Database No. 05507). The house is on land leased by Toro.

The house is a single storey mud block and timber framed residence with roughcast render finished walls and a corrugated iron gambrel roof in the Federation bungalow style that employed elements of inter-war Old English style. It has heritage significance because it is one of the few remaining substantial reminders of an important period in Wiluna's history. It was constructed for the General Manager of Wiluna Gold Mines, Mr C E Prior, during a period when that company was making a significant contribution to the Western Australian and Australian economies through the production of gold and arsenic. At the time, it was the largest producer of arsenic in the Commonwealth.

The large size of the residence symbolised the importance of the position of mine manager in the gold mining industry, although usually a manager's residence was built in the town supporting the mine while this one was built very close to the mine site:

> 'Mine Manager's House, Wiluna, was built to a high standard of design in its time for a residence of its size. It was well-constructed and used good trade practices. Elements such as the carpentry, joinery and cabinet work are very good examples of their type and period' (Register of Heritage Places – Assessment Documentation – Heritage Council of Western Australia).

The Wiluna District Hospital Group in Scotia Street, Wiluna, was established over a period of about 30 years from the beginning of the 20th century. It comprised the Morgue, Main Hospital Buildings, Hospital Quarters and the former Maternity Ward, now occupied by Tjukurba Art Gallery.

The former hospital buildings, now the shire offices, were permanently entered on the Western Australian Register of Places in 2010 (Heritage Council of Western Australia Database No. 03635). The buildings were registered because:

- 'The place is a good, highly intact example of an interwar period hospital facility and a fine and rare remaining example of its particular type in the State;
- The place was constructed in 1903 and closely associated with the re-establishment of large scale mining which led to the growth of Wiluna at a time when other regional centres were in decline;
- The place illustrates the changing hospital and medical practices and institutionalised racism through the provision of a separate ward for 'Natives';
- The site was used as the community medical centre from c.1903 to 1967 with the Morgue being a relatively intact remnant from the earlier stage of development; and
- The place has significance for generations of local people, first as a hospital and more recently as the administrative and community centre of the town as evidenced by the significant community effort to sustain it.' (Register of Heritage Places – Heritage Council of Western Australia)

No non-Indigenous heritage listed places occur in the vicinity of the mining area at Lake Maitland or locations for associated infrastructure.

15.5 Potential Impacts and Management

15.5.1 Indigenous Cultural Heritage

Toro's consultation with Aboriginal people and groups is discussed in Section 4.3.

Toro has undertaken surveys of the proposed mining area at Millipede with representatives of the Wiluna Native Title Holders. The alignment of the proposed haul road from Lake Maitland has also been surveyed where it would be on land held by the Wiluna Native Title Holders. As a result of this survey work and continuing consultation with the Wiluna Native Title Holders, Toro has identified that mining at Millipede can be undertaken without any impact on registered heritage sites, other heritage places or cultural heritage values identified by the Wiluna Native Title Holders.

At Lake Maitland, neither the one site of significance nor the smaller site identified in the most recent cultural heritage survey work would be impacted by the proposed development.

Recent archaeological surveys at Lake Maitland have also identified isolated artefacts.

This survey work has helped inform decisions about the proposed location of infrastructure at Lake Maitland. There are no mining or infrastructure requirements that would trigger the need to apply under the *Aboriginal Heritage Act 1972* to disturb a site or heritage place.

In considering measures necessary to meet the environmental protection objective for heritage, Toro has:

- Undertaken continuing consultation with Aboriginal people;
- Ensured sufficient information is available to identify sites of significance to Aboriginal people;
- Assessed whether there would be any impacts on Aboriginal sites of significance in accordance with EPA Guideline Statement No. 41; and
- Developed a Cultural Heritage Management Plan (CHMP) based on detailed archaeological and ethnographic information to ensure that impacts are not greater than predicted. The CHMP is attached as Appendix 8.

Toro is continuing to develop a process for managing Aboriginal cultural heritage sites and places by:

- Negotiating a mining agreement with the Wiluna Native Title holders to include arrangements for protecting and managing Aboriginal cultural heritage; regular consultation and liaison with Traditional Owners about impacts during the construction, operational,

closure and rehabilitation phases, including monitoring of heritage sites and places; maintaining access to land for cultural purposes which is compatible with mine safety; and Toro support for community development programs;
- Proposing to the Barwidgee and other Aboriginal people with an interest in Lake Maitland, the negotiation of a mining agreement, recognising that mining is not scheduled to begin at Lake Maitland before about 2022;
- Involving Aboriginal people in protecting and managing cultural heritage sites and places;
- Identifying mitigation measures including salvage and protection of sites;
- Establishing procedures to respond to the unanticipated discovery of cultural material remains; and
- Arranging cross-cultural awareness training for Toro's employees, contractors, subcontractors and consultants.

Toro would provide cross-cultural awareness training to all its employees, contractors, subcontractors and consultants engaged on the construction and operational phases of the Proposal. In 2010, 2013 and 2014, Toro conducted cross-cultural awareness programs for its Project team. The training emphasised respect for Aboriginal cultural heritage and the need to ensure heritage sites and places are protected, including through avoidance and mitigation measures. Through such training all employees and contractors during construction and operation would be:

- Aware of Aboriginal traditions and culture and the behaviours needed to respect such traditions and culture;
- Encouraged to develop relationships between Aboriginal and non-Aboriginal people based on mutual respect and trust; and
- Informed about the CHMP and their responsibility to comply with all of the plan's requirements.

It is possible that during the construction and operational phases of the Proposal, cultural material remains may be discovered. Should this happen, the CHMP would require an immediate cessation of work that could impact the materials while further investigations were undertaken.

The development of the CHMP is Toro's commitment to the management and protection of Aboriginal cultural heritage in a manner which respects the wishes of Aboriginal people. The objectives of the CHMP will be achieved through ensuring continuous consultation with Aboriginal people during planning, construction, execution, closure and rehabilitation, and in relation to any other activities Toro may undertake in the Wiluna region. The CHMP seeks to ensure that Toro's work is conducted in full compliance with all applicable laws and regulations relating to Aboriginal cultural heritage.

Toro's management team includes expertise in the development and management of Indigenous relations and experience in the management of cultural heritage issues associated with the construction and operation of other mines in Australia, including uranium mines. Toro's Approvals and Community Director has specific accountability to the Managing Director for all aspects of Indigenous relations, including cultural heritage.

The Board of Toro has endorsed the following Indigenous Relations Policy for the Wiluna Uranium Project:

Indigenous Relations Policy – Wiluna Project

Toro Energy will respect the culture of Indigenous people in our Project Area by:

- Involving them in discussions about our Project planning, implementation, operations, closure and rehabilitation
- Sharing information in a manner which best meets their needs
- Explaining how risks are to be managed
- Developing a Heritage Management Plan to minimise Project impacts and ensure continuing protection of cultural heritage sites
- Encouraging the use of their knowledge and skills in land management
- Supporting their cultural, social and economic aspirations through training, employment and business development opportunities
- Ensuring all our employees and contractors receive cultural awareness training

15.5.2 Non-Indigenous Heritage

In late 2010, the heritage-listed Mine Manager's House at Wiluna was severely damaged in a storm, losing its roof. Toro has undertaken restoration of the property with the installation of a new roof. A Heritage Council of Western Australia grant supported this work. In conjunction with the Wiluna Community, Toro is currently pursuing options for further refurbishment to enable the Mine Manager's House to become a functioning building to be used for community purposes. There would be no impact on the property from proposed mining at Millipede and Lake Maitland.

Table 15.4: Mitigation hierarchy in relation to potential impacts on heritage

Potential Impact	Mitigation Approach	Details
Disturbance of heritage places and sites during construction and operations	Avoid	The Millipede and Lake Maitland mining and infrastructure areas have been surveyed to identify heritage places and sites. Further heritage surveys will be undertaken as required prior to ground disturbance, including on the haul road alignment. Management and protection of heritage places and sites provided for in Cultural Heritage Management Plan.
Access to land for cultural purposes reduced during construction and operations	Minimise	For mine safety reasons, land access will need to be controlled. This will be provided for in an Access Protocol which will limit, to the extent practicable, areas to which access needs to be controlled. The Access Protocol will provide for consultation between Toro and Traditional Owners prior to the imposition of access limitations.

Potential Impact	Mitigation Approach	Details
Native Title rights affected	Minimise	Rights of Native Title Holders and Claimants will be affected by Toro's requirement for land access to conduct its operations. Toro is negotiating a mining agreement with the Wiluna Native Title Holders which will deal with all native title issues arising in relation to proposed mining at Millipede. Toro has proposed the negotiation of a similar agreement with those Aboriginal People, including the Barwidgee, who claim an interest in Lake Maitland.
Unanticipated discovery of cultural material remains during construction and operations	Minimise	Extensive heritage survey work has minimised the likelihood of the unanticipated discovery of cultural material remains. Mining agreements will include provision for the immediate cessation of work that could impact any materials while further investigations are undertaken in consultation with Traditional Owners.
Inappropriate behaviour by employees/contractors because of lack of cultural awareness	Avoid	All Toro employees and contractors will undertake cultural awareness training to emphasise respect for Aboriginal cultural heritage.
Deterioration of heritage-listed Mine Manager's House at Wiluna	Rehabilitate	Some restoration has been undertaken and Toro is pursuing options for further refurbishment to enable the property to become a functioning building to be used for community purposes.

15.6 Commitments

- Avoidance where practicable of registered heritage sites and other heritage places during mine development and operation;
- Implementation of a CHMP to apply at both Millipede and Lake Maitland to include heritage management rules established in consultation between Toro and Traditional Owners;
- Regular monitoring and auditing of compliance with the CHMP and heritage management rules;
- Negotiating mining agreements with Native Title holders and claimants stipulating compliance with the CHMP and heritage management rules;
- Ensuring all employees, contractors, subcontractors and consultants have cross-cultural awareness training;
- Procedures for dealing with the unanticipated discovery of cultural heritage remains; and
- Further refurbishment of the heritage-listed Mine Manager's House at Wiluna to enable it to be a functioning building used for community purposes.

15.7 Outcomes

No adverse effects on historical and cultural associations or natural heritage.

16 REHABILITATION AND DECOMMISSIONING

16.1 Objective

To ensure that premises are decommissioned and rehabilitated in an ecologically sustainable manner.

16.2 Relevant Legislation and Policy

Closure and rehabilitation of the Proposal must, as a minimum, satisfy general requirements set out in the following Western Australian legislation:

- *Environmental Protection Act 1986*;
- *Contaminated Sites Act 2003*;
- *Mining Act 1978*;
- *Mines Safety and Inspection Act 1994*;
- *Mining Rehabilitation Fund Act 2012*;
- *Dangerous Goods Safety Act 2004*;
- *Radiation Safety Act 1975*; and
- *Radiation Safety (Transport of Radioactive Substances) Regulations 2002*.

EPA Guidance Statement No. 6 (EPA, 2006) provides guidance on the rehabilitation of terrestrial ecosystems following disturbance. The statement states that the key aims of mine rehabilitation are to:

- Ensure the long-term stability of soils, landforms and hydrology required of sites; and
- Partially or fully repair the capacity of ecosystems to provide habitats for biota and services for people.

Actions relevant to rehabilitation planning and design include the identification of closure objectives (developed in consultation with stakeholders), as well as the development of clear targets for rehabilitation that can be effectively monitored and audited to confirm objectives are achieved.

The methods by which closure and rehabilitation outcomes may be achieved and the standards by which closure planning, design and implementation will be assessed are described in a range of guidelines and related publications, including:

- DMP, 2013. *Tailings Storage Facilities in Western Australia – Code of Practice*;
- Chamber of Minerals and Energy WA Inc, 2000. *Mine Closure Guideline for Mineral Operations in Western Australia*;
- Australian and New Zealand Minerals and Energy Council and Minerals Council of Australia, 2000. *Strategic Framework for Mine Closure*;
- DoITR, 2006. *Mine Closure and Completion, Leading Practice Sustainable Development Program for the Mining Industry*;
- DoITR, 2006. *Mine Rehabilitation, Leading Practice Sustainable Development Program for the Mining Industry*;
- EPA, 2006. *Guidance Statement No. 6 Rehabilitation of Terrestrial Ecosystems*;
- International Council on Mining & Metals, 2008. *Planning for Integrated Mine Closure: Toolkit*;
- Department of Environment and Resource Management, 2008. *Guideline 18: Rehabilitation requirements for mining projects*. Queensland;
- EPA, 2009. *Environmental Assessment Guideline No. 4 -Towards Outcome Based Conditions*; and

- EPA and DMP, 2015. *Guidelines for Preparing Mine Closure Plans*.

16.3 Proponent Studies and Investigations

To assist in identifying the closure risks arising from implementation of the Proposal and therefore assist in closure planning, Toro has undertaken a series of studies.

16.3.1 Leachability of Ore

In order to assess any potential impact arising from an unplanned closure of operations that would result in the stockpiling of unprocessed ore, Toro commissioned ore leachability tests. The results are in Table 16.1. They confirm that the ore is relatively benign.

Table 16.1: Results of ore leachability tests

Ore Constituent	ASLP 1, mg/L	CL1, mg/kg	Wiluna ore, water leachable metal, mg/L	Wiluna ore, total metals, mg/kg	Wiluna ore, leachable metal as a percentage of total metal, %
Aluminium	--	50,000	<0.1	23,110	--
Arsenic	0.5	500	0.002	20	0.2
Barium	--	50,000	0.06	370	0.38
Beryllium	0.1	100	<0.01	<0.5	--
Cadmium	0.1	100	<0.002	<0.5	--
Chromium (VI)	0.5	500	<0.01*	50*	<0.004*
Cobalt	--	50,000	<0.01	<5	--
Copper	--	50,000	0.02	20	0.4
Lead	0.1	1500	<0.01	10	--
Manganese	--	50,000	<0.01	215	--
Mercury	0.01	75	<0.0002	Not tested	--
Molybdenum	0.5	1000	<0.01	<5	--
Nickel	0.2	3000	<0.01	15	--
Selenium	0.5	50	<0.001	Not tested	--
Silver	1	180	<0.01	<1	--
Thorium	--	--	0.002	4.0	1
Uranium	--	--	0.001	537.5	0.004
Vanadium	--	50,000	0.01	200	0.1
Zinc	--	50,000	0.05	25	4

Note: The ore was characterised using the DER waste classification (DER 2009). Chromium concentrations are for total, not hexavalent chromium. A dash (--) means no value has been defined or no percentage could be calculated because the concentrations of metals were less than the analytical limit of reporting.

16.3.2 Physical and Geochemical Characterisation of Waste Rock Material

As discussed in Section 11.4, Millipede, Centipede, Lake Maitland and Lake Way are all classified as surficial calcrete associated uranium deposits due to their equivalent geological/geomorphological setting, mineralogy and theory (or theories) of genesis as outlined by Brunt (1990). In the Yilgarn of Western Australia, these four deposits are not unique. Yeelirrie, Lake Raeside, Lake Mason, Nowthanna, Thatcher Soak and Dawson Hinkler are all of the same uranium deposit classification. All these deposits have an ore mineralogy of almost 100% carnotite ($K_2(UO_2)_2(VO_4)_2{\cdot}3H_2O$) and are associated with calcium and magnesium carbonates in an oxidised setting near the surface (within 1–2 m depth) with valley fill sediments (sands, silts and clays) in broad palaeovalleys, trunk drainage systems and playas (Brunt, 1990).

Given these fundamental similarities, the mineralogical and chemical composition of bulk material excavated from any of these deposits, whether in the form of ore or waste rock, will be for all intents and purposes, the same. The current geological interpretation of the Millipede and Lake Maitland deposits by Toro geologists using sonic and diamond core has demonstrated this.

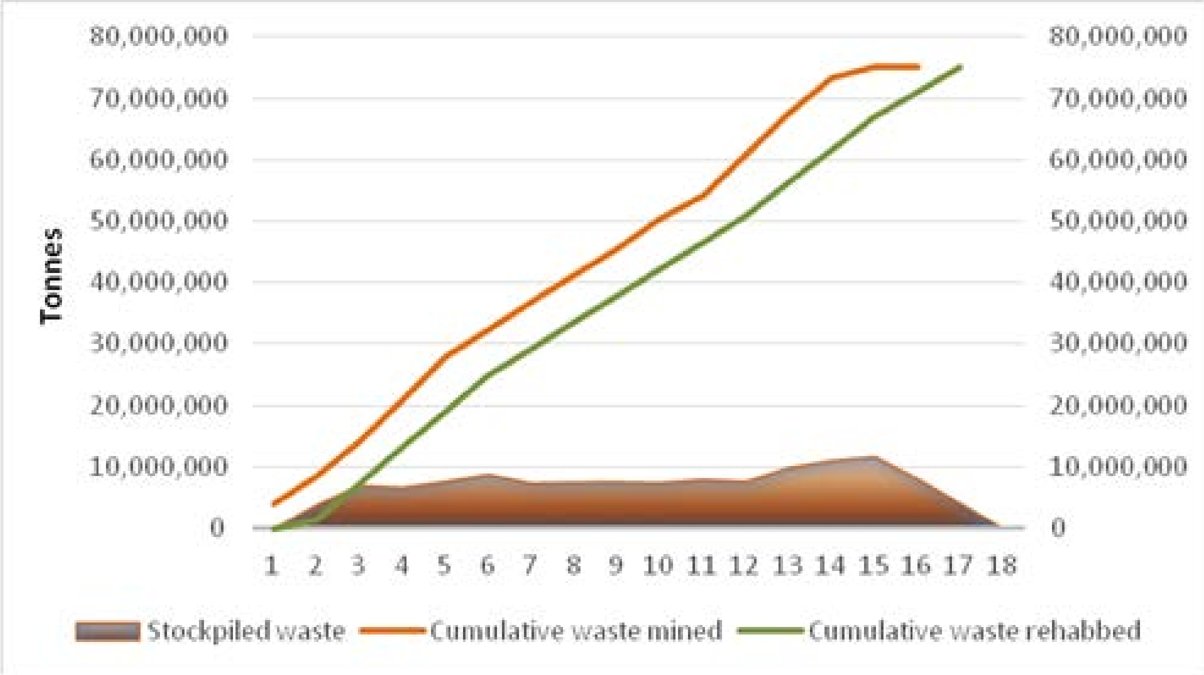
The only lithological changes that would occur within waste stockpiles, or any stockpile for that matter (ore on the ROM or low grade ore), would be due to changing dominances within different parts of the deposits. For example, some areas have more clay than calcrete and some more calcrete than clay. This is evidenced in the representative sampling that has occurred for waste characterisation whereby whilst the calcium and magnesium carbonates dominate the system, there can be considerable differences in the abundances of particular clay species or lithology, such as silcrete (portrayed by quartz content), depending on the exact locations the samples have been collected from within the deposits. Whatever the case, however, mineralogical and geochemical analyses show that bulk material from all deposits, whether ore or waste, will be relatively benign oxidised sands, silts and clays with calcrete (often dolomitic).

16.3.3 Mining Waste Generation

Over the course of the operation and across all four deposits, the generation of wastes would remain fairly consistent. This is due to similarities in all four deposits including their grades, depths and geographical extents. Figure 16.1 demonstrates how mining wastes would be generated by the Project.

The orange line shows the cumulative tonnages of waste mined over the duration of the Project (including mining at Centipede and Lake Way). After waste is taken from an area being mined, it is stockpiled and later returned as backfill when a suitable void is available. As mining progresses, the void space available for waste keeps up with the volume of waste generated as shown by the orange and green lines remaining almost in parallel. The green line, representing waste rehabilitation through return of waste as backfill, remains lower than the cumulative waste generation line during the life of mining, but by the end of operations the entire quantity of waste has been rehabilitated. The brown polygon at the base of the graph shows the annual total tonnage of waste in stockpiles at the end of each year.

Figure 16.1: Mining waste generation and rehabilitation



16.3.4 Acid and Neutral Rock Drainage

There are four key fundamentals to understanding the potential chemistry of drainage from any stockpile or long term final landform at the Wiluna Uranium Project. They are:

1. As discussed above and in Section 11.4, all the deposits forming the Wiluna Uranium Project (Millipede, Centipede, Lake Maitland and Lake Way) are located within a completely oxidised setting only 1–2 m from the surface (Toro geological observations (Figure 16.2 and Figure 16.3) and Brunt, 1990);
2. All of the deposits are hosted by relatively benign oxidised sands, silts and clays within deltas and playas in broad palaeo-valleys (Toro geological observations (Figure 16.2 and Figure 16.3) and Brunt, 1990);
3. Whilst varying amounts of different clay species are present as well as gypsum (the latter mostly above the ore body in the waste) the geochemical environment is dominated by calcium and magnesium carbonate precipitates and concretions (Toro geological observations (Figure 16.2 and Figure 16.3) and Brunt, 1990); and
4. The ore mineral in all calcrete associated uranium deposits is almost entirely the potassium uranyl vanadate, carnotite $(K_2(UO_2)_2(VO_4)_2{\cdot}3H_2O)$ (Brunt, 1990, Cameron, 1990, Bastrakov *et al.*, 2010), a relatively stable mineral within the chemical conditions and timescales relevant to the Wiluna Uranium Project.

Figure 16.2: Geological cross-section – Millipede

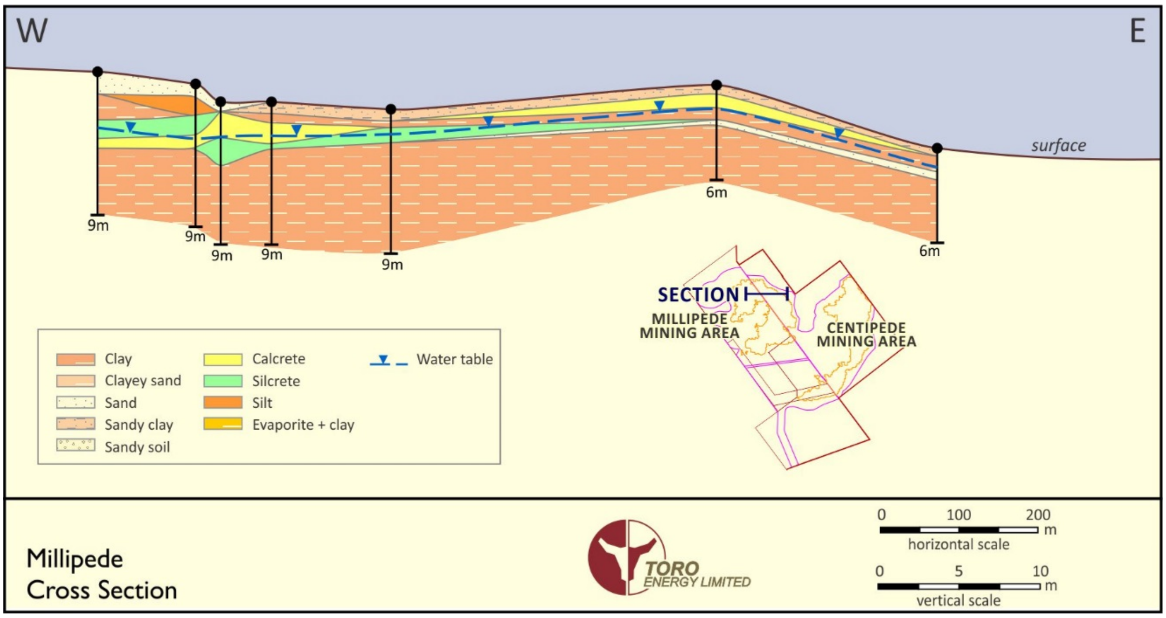
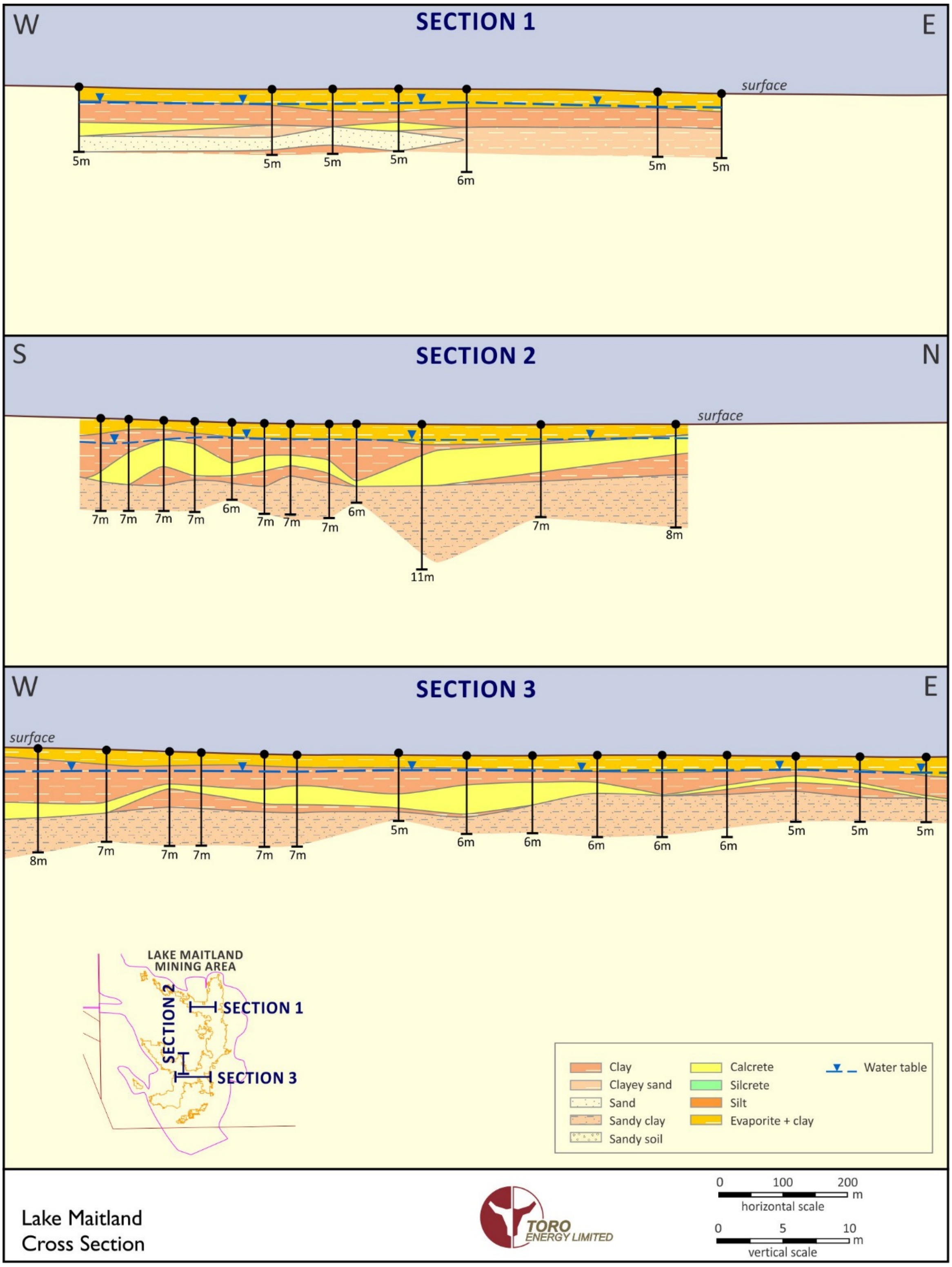


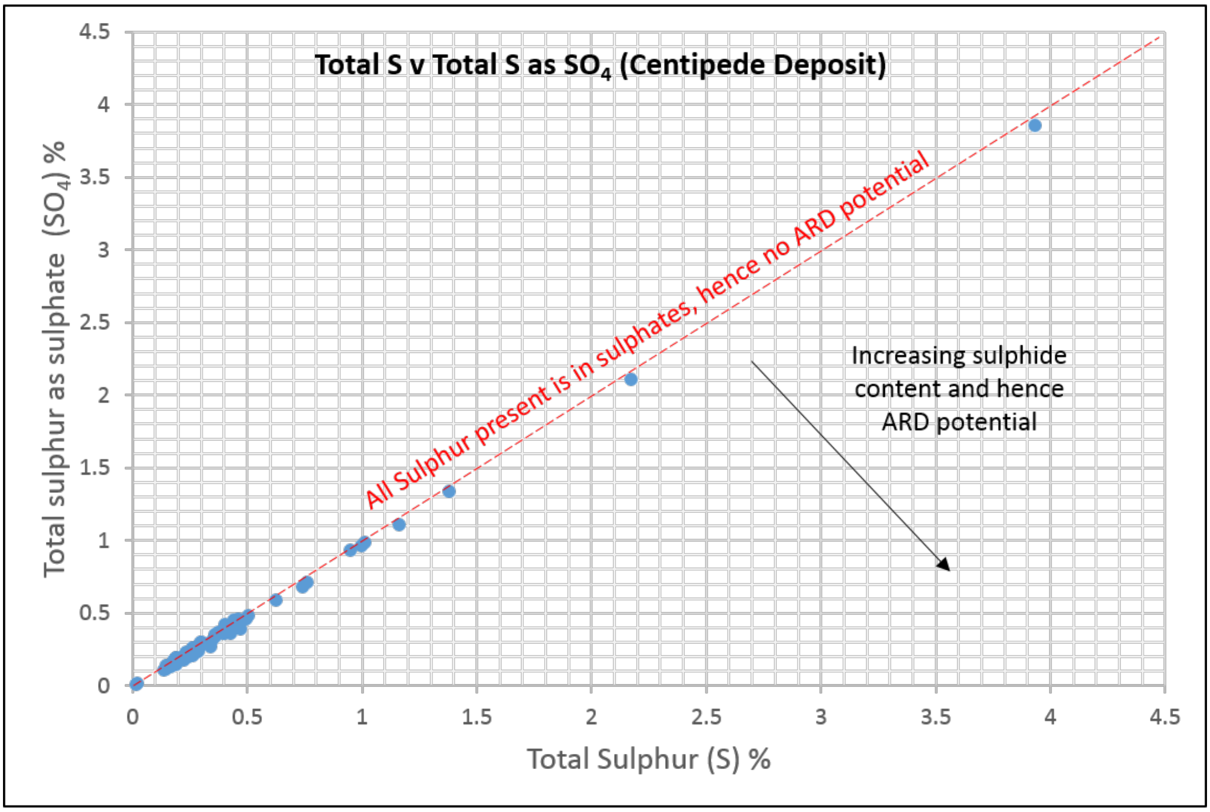
Figure 16.3: Geological cross-section – Lake Maitland



The first of the above fundamentals means that there are no potential acid forming minerals present in the geological host, such as iron sulphides, since such minerals need reducing conditions to form. Toro analysed for both Total Sulphur and Total Sulphate in sonic drill core from the 2012 resource drilling program at Centipede; a comparison of the results shows that all sulphur present is in the form of sulphates (dominantly gypsum), not sulphides (Figure 16.4). Thus, there is no potential for direct acid rock drainage (ARD) nor neutral drainage from acid forming reactions occurring inside the stockpiles or final landforms.

In effect, unlike deeper deposits hosted in hard rock (fresh rock), there is very little difference in the oxidation-reduction conditional balance (commonly known as redox) between the setting of the deposit, at 1–2 m from the surface, to a stockpile at the surface. Changes in redox and the chemistry associated with the main redox chemical reactions are the main controls on weathering, ARD and neutral drainage issues.

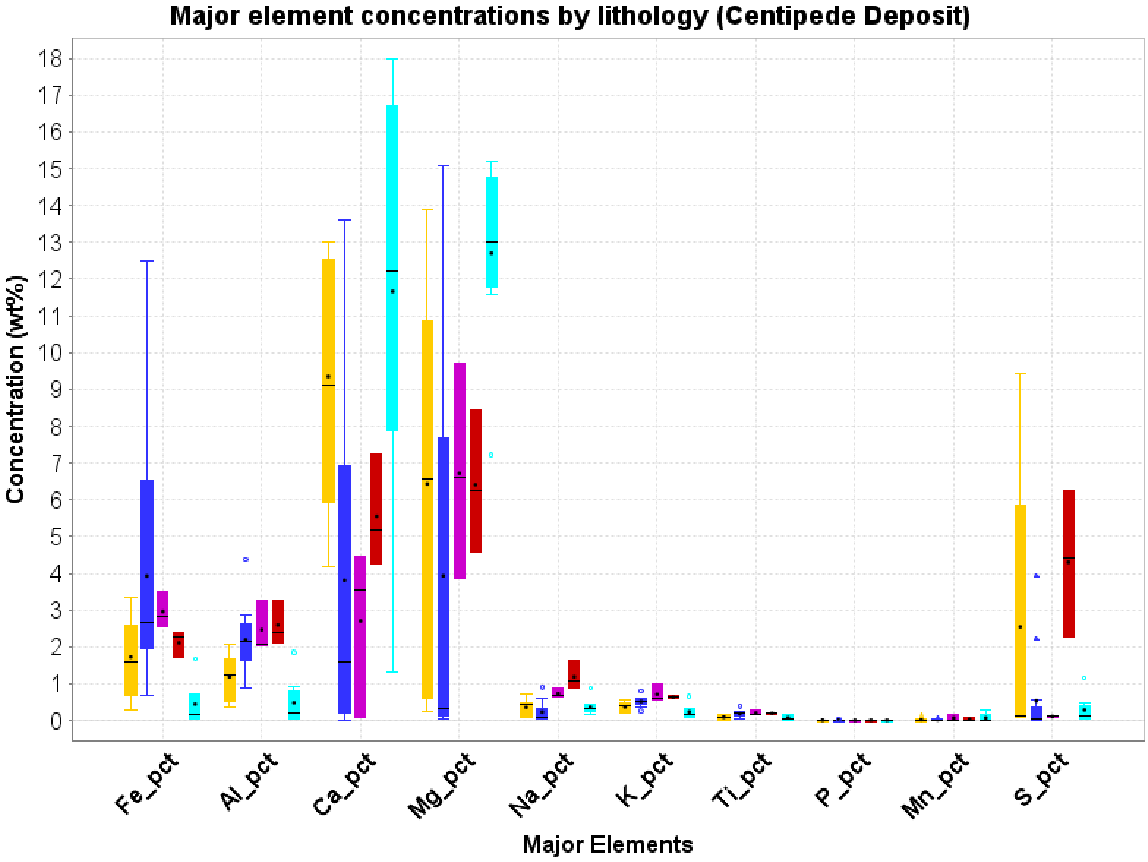
Figure 16.4: Sonic drill core analysis to compare Total Sulphur (S) and Total Sulphate (SO_4)

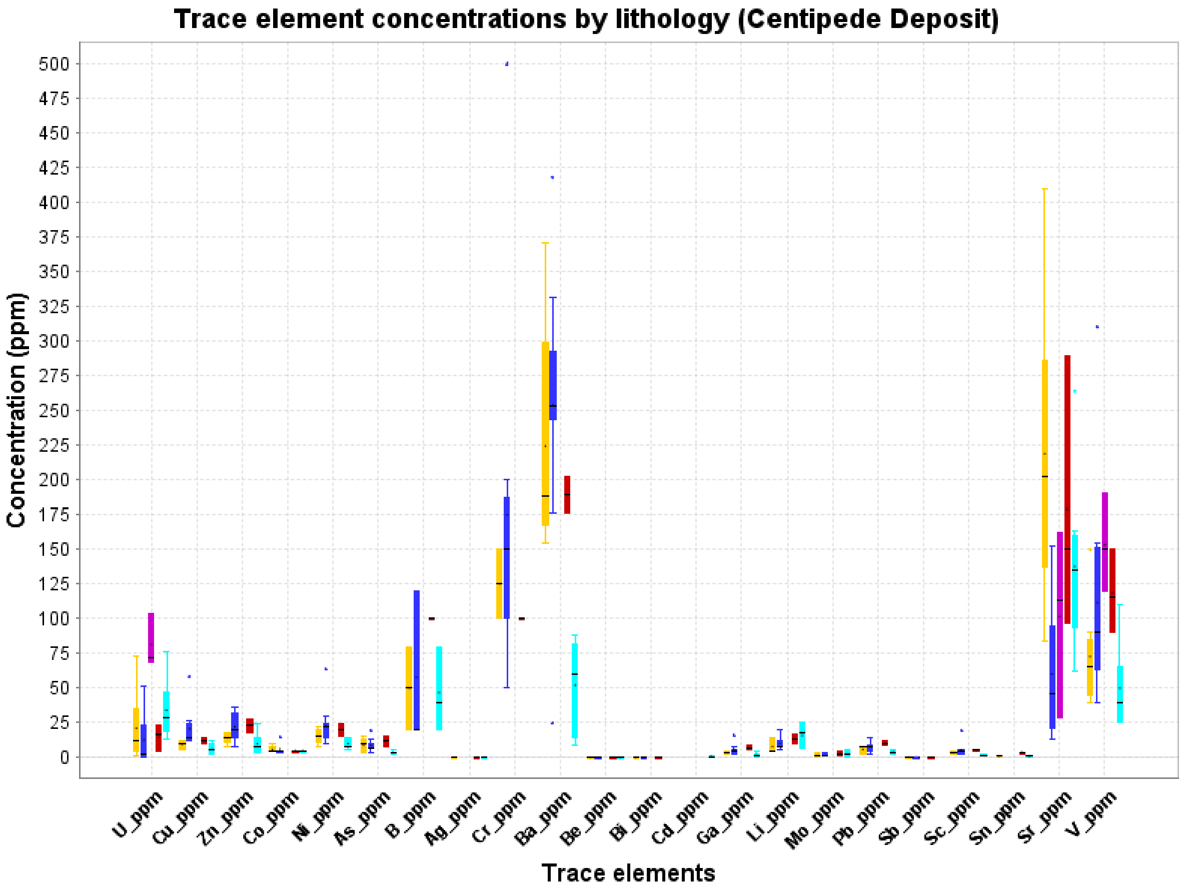


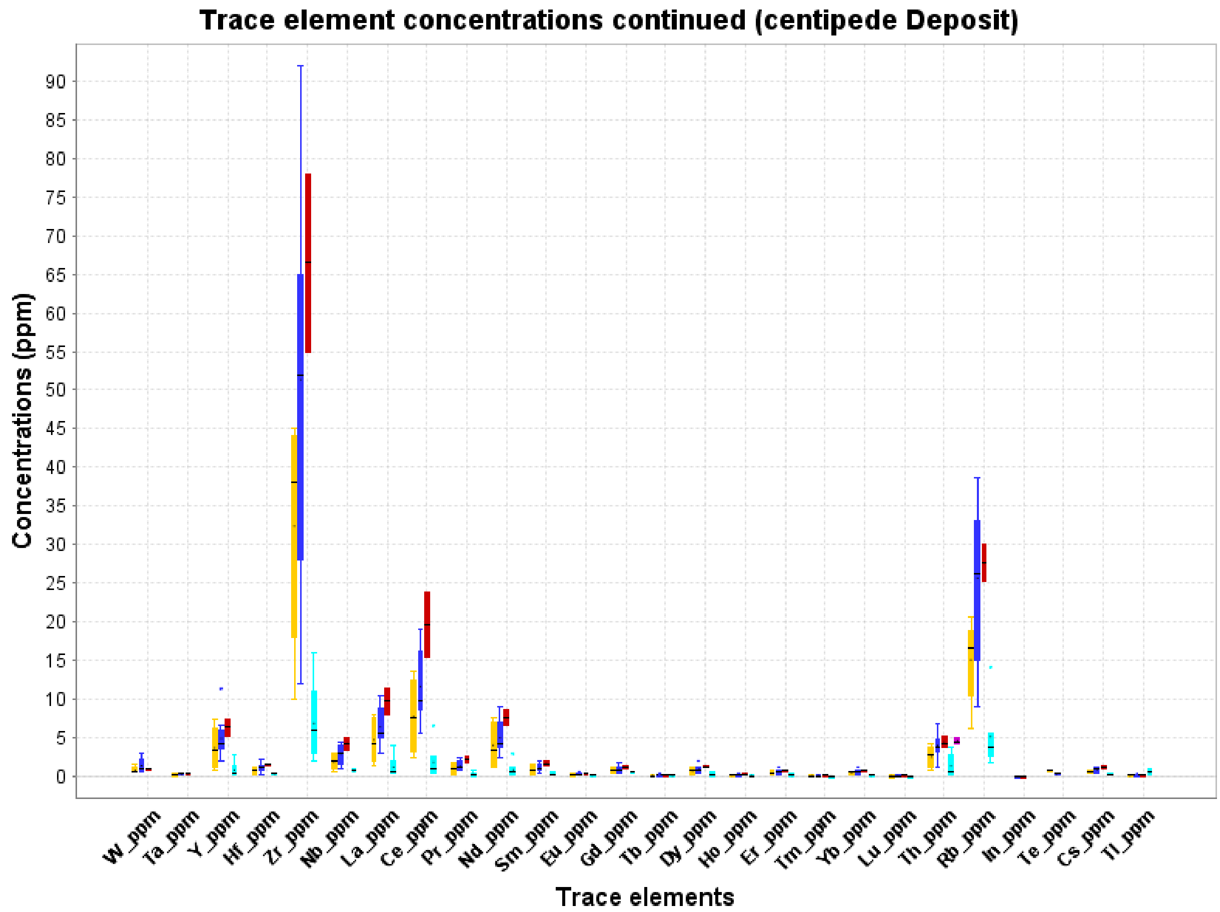
Note: Chart shows that for all intents and purposes, all S is present as SO_4, mostly in the form of Gypsum ($CaSO_4 \cdot 2H_2O$), meaning a complete lack of any sulphides and therefore potential production of free hydrogen ions and thus acid rock drainage from the oxidation of them.

In addition to the absence of potential acid forming minerals, the second and third fundamentals above mean that there is very little of most elements available to be leached from the host material if presented to stockpiles. In other words, it is relatively benign material. Table 16.1 provides results of ore leachability tests. Figure 16.5, again from samples of sonic drill core from the 2012 resource drilling, shows major and trace element concentrations in the different lithologies of waste and low grade ore to be extremely low, apart from those related to calcrete and dolocrete (calcium [Ca], magnesium [Mg], barium [Ba] and strontium [Sr]), gypsum (sulphur [S]), some of the more resistate minerals in the sands (iron in iron nodules [Fe], boron, [B], chromium [Cr], barium [Ba], zirconium [Zr] and rubidium [Rb]) and the aluminium (Al) in the clays.

Figure 16.5: Major and Trace Element Concentrations in Waste and Low Grade Ore Lithologies







LEGEND for Figure 16.5

- Calcrete/dolocrete
- Sands
- Silts
- Clays
- Silcrete

Note: Boxplots showing the range of concentrations of major and trace elements in the main lithological units of the Centipede Deposit, Wiluna Uranium Project for waste and very low grade ore (approximately less than 105 ppm U). Samples are from sonic drill core from the 2012 resource drilling program over the Centipede Deposit. The lithologies are the same lithological units used by Toro geologists across all of the Wiluna Uranium Project calcrete associated deposits, including Millipede and Lake Maitland.

The fourth fundamental outlined above relating to the ore mineral in all calcrete associated uranium deposits being carnotite is important because, again, carnotite as a mineral that has precipitated in an oxidised environment, will not be introduced to chemical conditions of any vast difference in the stockpiles or final landforms. Uranium solubility modelling work by Bastrakov *et al.* (2010) has shown that carnotite is a relatively stable solid phase in the environments and timeframes relevant to the Wiluna Uranium Project.

16.3.5 Timing of Land Disturbance

Toro has estimated the timing of land disturbance based on its current mining schedule (Figure 16.6, Figure 16.7 and Figure 16.8). Mining is scheduled to commence at Centipede as shown in Year 1 of Figure 16.6. Mining at Centipede would start away from the lake and gradually progress north. By Year 2 tailings are being deposited into the first mining area. In Year 3 mining would move west and also commence at the Millipede deposit. By this stage, significant void space has been opened up for tailings. Rehabilitation commences in Year 4 to allow tailings time to consolidate sufficiently to allow material to be backfilled over the tailings.

The mining at Centipede and Millipede would continue until Year 5, at which time mining would commence at Lake Maitland. At Millipede, sufficient pit void space needs to be left to take tailings generated from the processing of ore mined at Lake Maitland, and at Centipede the same is the case for Lake Way tailings.

At Lake Maitland, as mining progresses rehabilitation would be quicker as there is no need to allow time for tailings to settle. The pits at Lake Maitland would be backfilled with suitable material and rehabilitated immediately. By the end of Year 12, mining has ceased at Lake Maitland and the entire mining area is being rehabilitated. Toro would ensure that no mine pits are left at Lake Maitland at the end of operations there to ensure no pit lakes are created.

Between Years 13 to 18, the Lake Way deposit would be mined. This is not shown on the figures below as mining at Lake Way has already been the subject of EPA Assessment 1819 and mining there would follow the sequence assessed (Toro, 2011a, Section 2.5.6). During mining at Lake Way, tailings are still being deposited at Centipede and the consolidated TSF is still being rehabilitated. By the end of Year 18, all of Centipede and Millipede has been rehabilitated, as has Lake Way and Lake Maitland.

Figure 16.6: Land disturbance timing - Years 1–6

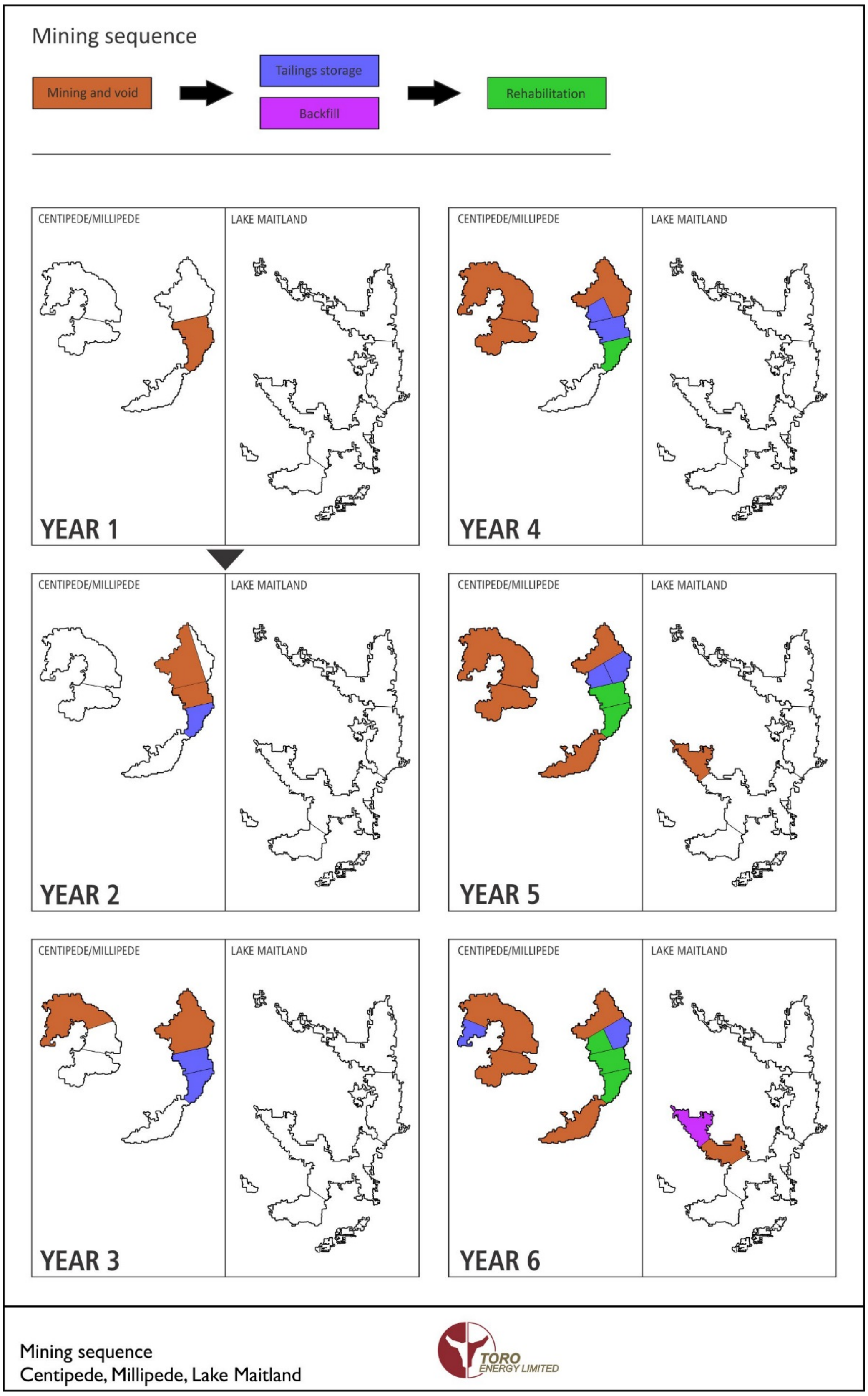


Figure 16.7: Land disturbance timing - Years 7–12

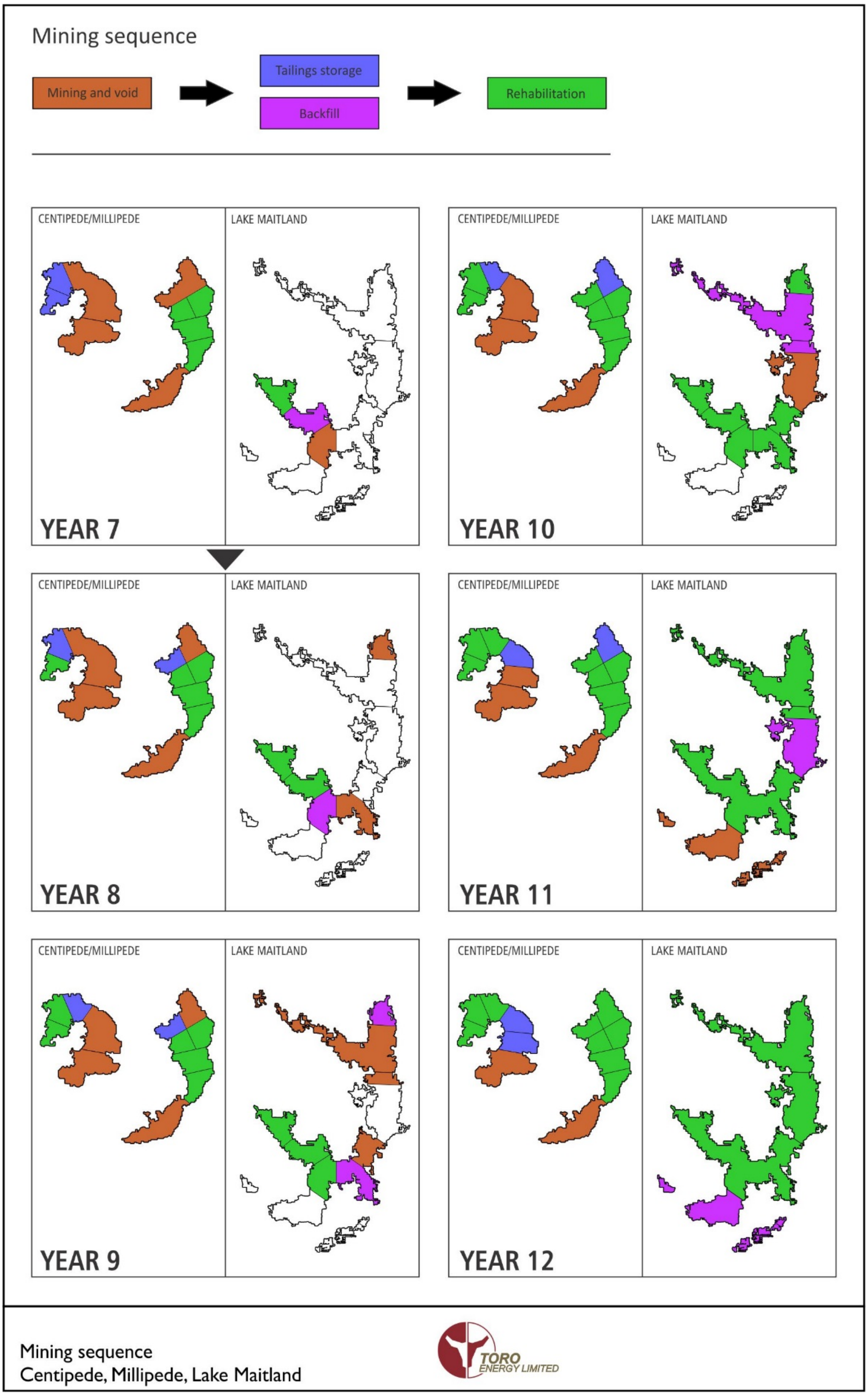
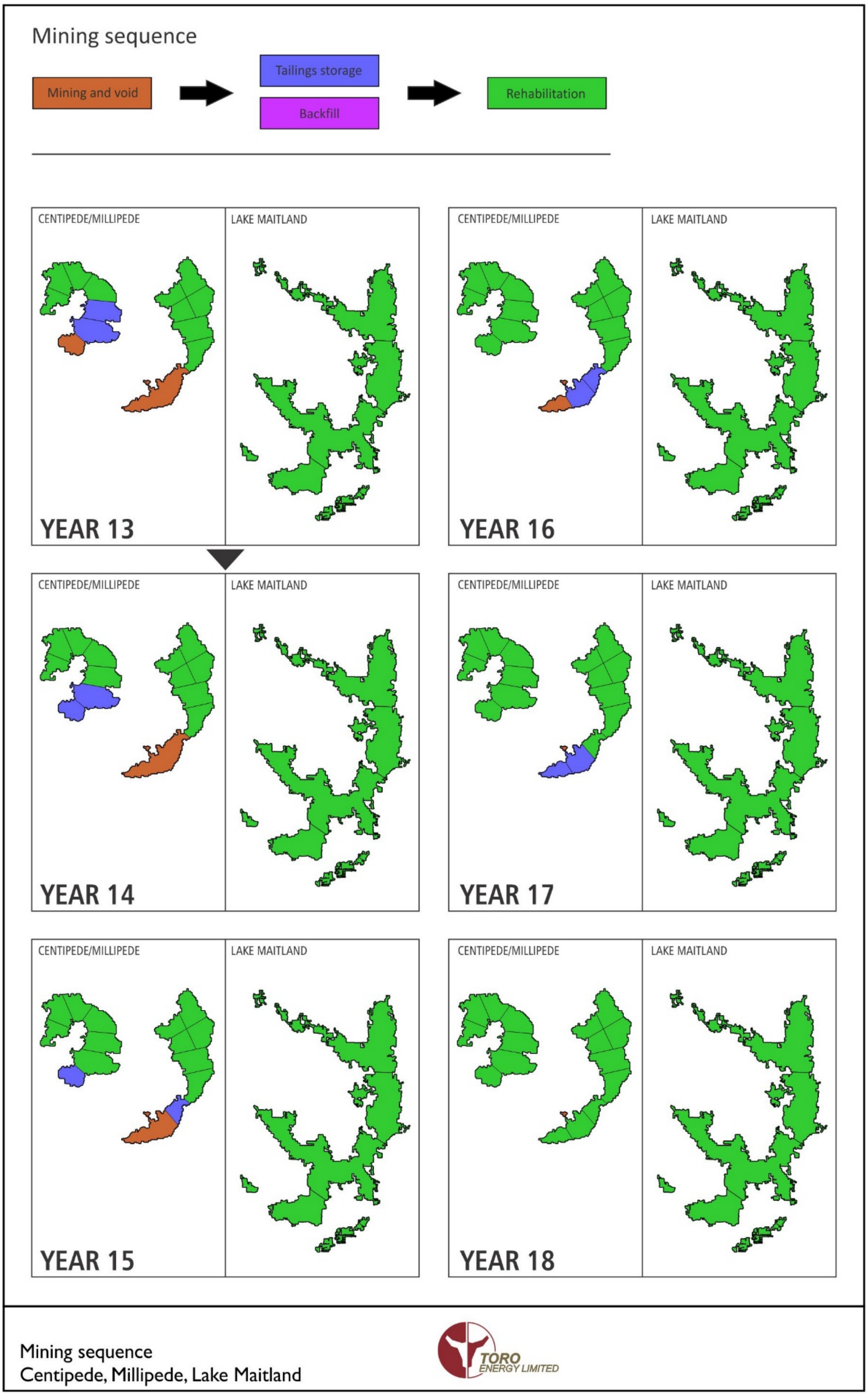


Figure 16.8: Land disturbance timing - Years 13–16



16.3.6 Storage of tailings in pit voids

This PER assesses mining at Millipede and Lake Maitland and the storage of all the tailings produced from processing of the ore from both deposits in the mined out voids at Millipede. Toro has already received approval (EPA Assessment 1819 and EPBC 2009/5174) for the storage at Centipede of all tailings produced from processing of the ore from mining both the Centipde and Lake Way deposits.

Toro's proposals for tailings storage at Centipede were discussed in its ERMP for mining at Centipede and Lake Way (Toro Energy, 2011a) and its Response to Submissions on the ERMP (Toro Energy, 2012a).

As the Millipede and Centipede tenements are immediately adjacent, mining of the Millipede pit would be a continuous extension of the mining activities at Centipede already approved. Toro's technical studies have confirmed that all tailings from the Wiluna Uranium Project, including its extension, can be contained within the proposed Tailings Storage Facility (TSF) at Millipede-Centipede.

Tailings samples have been tested to determine the density at deposition and after consolidation for long term stability such that rehabilitation and closure can be undertaken.

Knight Piésold (2013a) has recommended an initial deposition density of 0.80 – 0.83 tonnes per cubic metre (t/m^3) which would then consolidate to an average dry density of 0.96 t/m^3. At this density, based on the mine and processing schedule, would require 20.9 million cubic metres (Mm^3) of volume to contain all of the tailings. The possibility exists to filter the tailings if this is the best Project option. This has the potential to increase the water recovery and tailings density to 1.4 t/m^3 which in turn decreases the volume required to contain tailings to 14.3 Mm^3.

The basic parameters for finalising the design of the Millipede-Centipede mining operations are:

- Total depth of mining of up to 15 m
- No compromise of the drawdown scenario defining the 0.5 m groundwater drawdown perimeter

Using the pit surface area and depth parameter, it is estimated that the total mining pit void at Millipede-Centipede can be up to 39.5 Mm^3. Internal civils could reduce the volume available by up to 20%, leaving 31.6 Mm^3 for tailings storage.

16.3.7 Mine Closure

As part of the rehabilitation of the mine pits, space would be allowed to contain any materials that cannot be taken off site.

In the lead up to closure, reuse and recycling opportunities for fixed and mobile plant and infrastructure would be considered. This could include removal of selected equipment for use by a third party, or leaving some equipment or infrastructure (for example, water supply bores, power transmission infrastructure or access roads) in situ for alternative beneficial uses such as for pastoral or community purposes. Where no feasible or practicable alternatives were identified, the Project components would be decommissioned.

Total estimates of concrete, steel, pipelines and other materials available for salvage or to be disposed of at decommissioning following mining at Millipede, Centipede, Lake Maitland and Lake Way will be provided in the Mining Proposal.

At the end of its useful life, the processing plant would be decommissioned, dismantled and either buried in mined-out voids or removed. Decommissioning of the processing plant and the accommodation camp which would support mining at Millipede/Centipede was included in EPA Assessment 1819.

The infrastructure to support mining at Millipede would be the same as that required for Centipede. There are no additional installations apart from internal haul roads needed to facilitate mining at Millipede. For this reason, there are no waste materials (such as concrete and steel) that would need to be removed from Millipede that are additional to those to be removed from Centipede. The roads put in place to connect the two deposits would be ripped up and re-spread with topsoil and revegetation, where required.

The underground pipeline connecting the processing plant with the Lake Maitland borefield would likely be left in place. The advantage of this is that after installation the area cleared for the pipeline would be rehabilitated and have had almost 20 years to recover. Removal of the pipeline at that stage could interrupt ecosystems and spread weeds. Accordingly, the environmental benefits of leaving the pipeline in place outweigh any benefits of its removal. Infrastructure at each end of the pipeline would be removed.

The haul road connecting Lake Maitland to the processing plant would be rehabilitated by ripping, spreading with topsoil and revegetated, if required. As this haul road would not be required beyond Year 13 of the operation, it is likely that this rehabilitation would take place well in advance of Project closure.

At the Lake Maitland site, all above ground installations such as workshops, the accommodation camp and any office buildings would be removed. It is likely that the office buildings and camp would be sold and taken off site. Similarly, workshops are also likely to be removed from site as they would not be contaminated beyond the point of remediation. Fuel tanks and other hydrocarbon storage containers would be taken back to the workshop at Centipede where they would be used for the remainder of the Project’s life. During operations at Lake Maitland, all rubbish and waste hydrocarbons would be sent to the Centipede site for disposal and/or remediation.

It is likely that concrete footings at Lake Maitland would need to be disposed of inside the mine pit. The volume of concrete to be removed has been estimated based on the approximate footprint of the mine buildings and is presented in Table 16.2. The engineered pads on which the stockpiles would sit are likely to be compacted clay and are not included within the calculation. These are also likely to be disposed of within the pit.

Table 16.2: Final materials and waste management – Lake Maitland

Installation	Footprint	Approximate Volume of Concrete to be Removed
Mine workshops	2 ha area allowed for workshop floors	2000 m^3
Mine camp and offices	20 dongas, plus footpaths, parking and associated infrastructure	520 m^3

16.3.8 Landform Evolution Modelling

Modelling was undertaken by Landloch to assess the long-term stability of the post-closure landforms, particularly over the rehabilitated tailings storage facility (Landloch, 2015 – Appendix 10.10). Samples were taken of the three most common soil types found across the Project area. The clay pan material was found to be hypersaline, as expected, and was only suitable for use in rehabilitating reconstructed clay pan areas.

The two other soil types, the lake playa sand and the dune sand, were found to have indistinguishable properties and were considered to be the same material. To model the erosion potential of reformed structures, a 20 m high dune with an 18° batter configuration was chosen. This structure represents a reformed dune constructed with considerably steep walls. Landloch’s erosion model found that material across the Project area was not susceptible to erosion.

16.3.9 Fate of Contaminant and Transport Modelling

For a full characterisation of waste rock material and tailings associated with each deposit refer to Section 11.

At the Millipede and Centipede deposits, Toro is planning to backfill mine voids with tailings. Mine voids would be prepared for tailings with a layer of compacted clay to serve as a trap to capture mobilised uranium and other contaminants, and to also slow the movement of water into and out of the TSF. Tailings would then be deposited into the void to a depth of 3 m below the top of the pit. The tailings cap would be a minimum 2 m thick and comprise a compacted multi-layer cover with a radiation control layer at the base. Further details of the TSF design are given below.

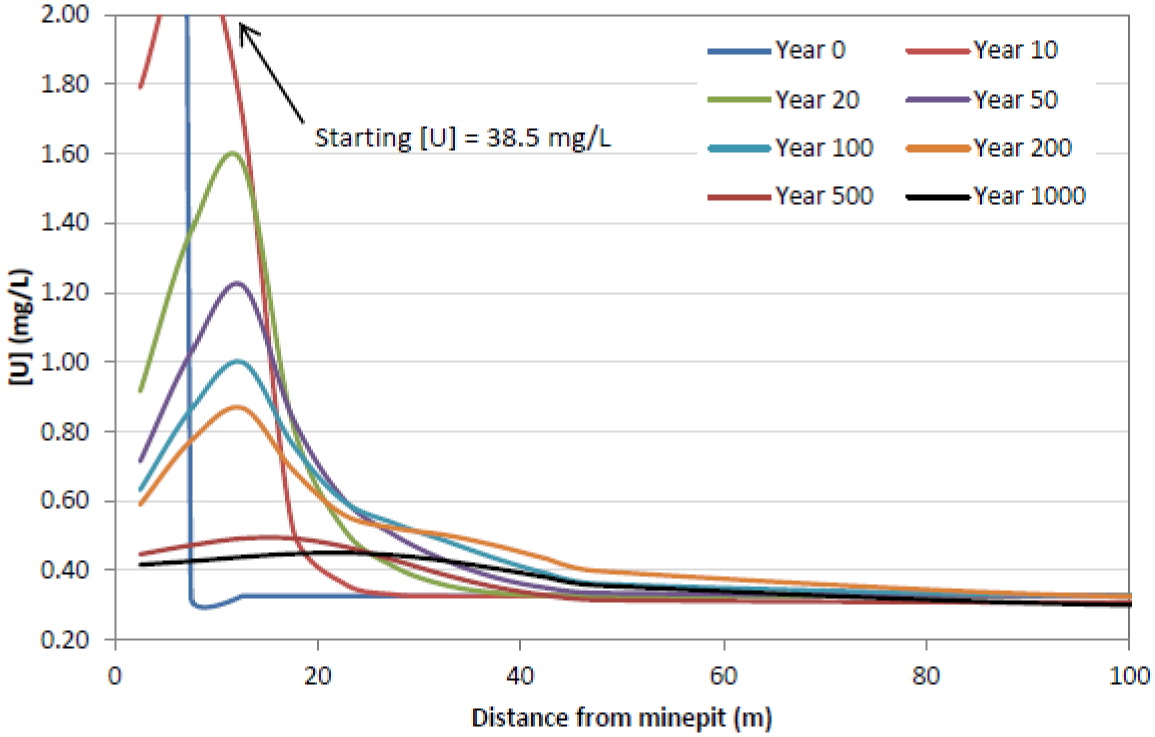
To demonstrate that in-ground tailings is a safe and viable option for the long-term storage of tailings, Toro has previously undertaken geochemical and solute transport modelling of seepage into the surrounding groundwater environment using independent consultants (Knight Piésold Consulting, 2011). This was completed as part of the assessment of mining at Centipede and Lake Way (EPA Assessment 1819 and EPBC 2009/5174). The same management method is proposed for tailings produced from ore mined at Millipede and Lake Maitland.

Toro's fate of contaminant modelling assessed how far from the TSF contaminates would flow after 10,000 years. It adopted conservative assumptions, including no clay barrier in the TSF.

The results showed that there would be an initial pulse of uranium resulting in a peak in concentration (40.8 mg/L) in the aquifer in close proximity to the mine pit (<10 m). With time, the uranium plume would disperse due to the movement of the groundwater. After 1000 years, the released uranium (38.5 mg/L) would drop appreciably to concentrations of less than 0.5 mg/L at distances of up to 45 m from the mine pit, and to below 0.4 mg/L at distances greater than 45 m. This significant drop in uranium concentrations is likely due to adsorption on to the calcite and associated iron oxide surfaces (Knight Piésold Consulting, 2011).

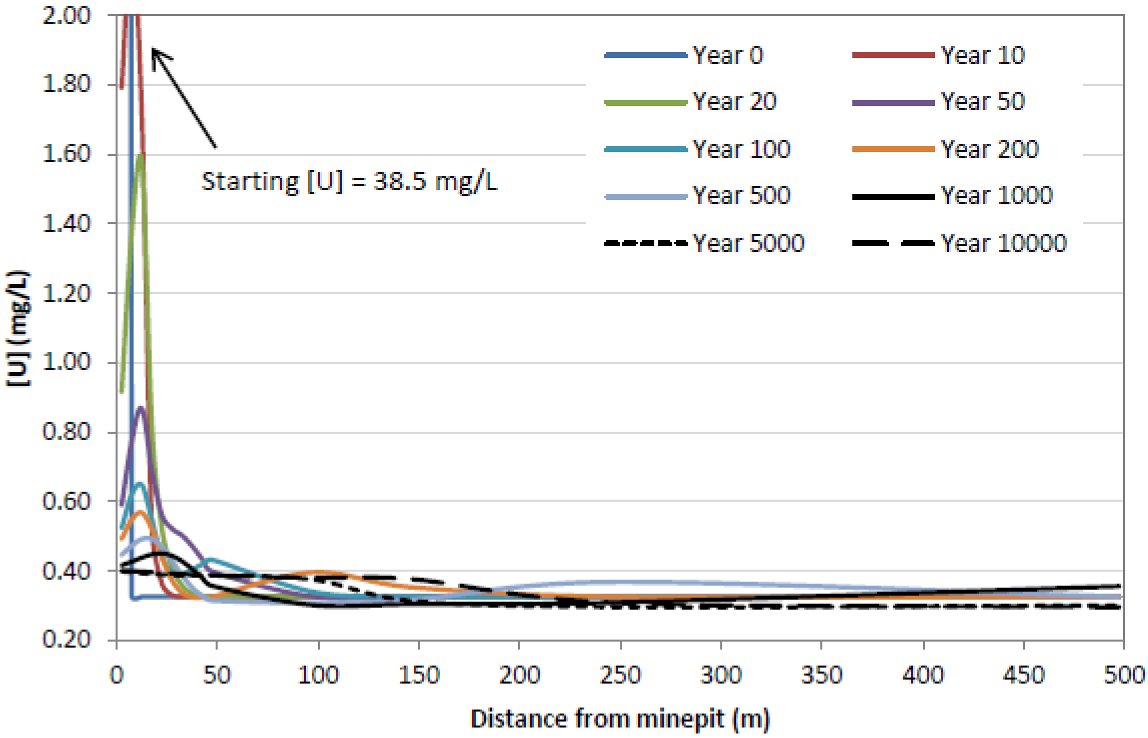
The model prediction for a 10,000 year period is shown in Figure 16.9 and Figure 16.10. It is predicted that the groundwater uranium concentration would remain below 0.40 mg/L across all distances from the mine pit, and that the majority of uranium released in the leachate would be adsorbed or precipitated out of solution at distances greater than 250 m.

Figure 16.9: Predicted U transport from tailings over a 1000 Year period with a flow velocity of 0.5 m/a



Source: Soilwater (2012)

Figure 16.10: Predicted U transport from tailings over a 10,000 Year period



Source: Soilwater (2012)

During this assessment, at the request of the DER, Toro commissioned Dr Henning Prommer, a Principal Research Scientist at CSIRO and Winthrop Research Professor at the University of Western Australia, to update the original model to ensure all chemical speciation/complexing, and therefore uranium solubility/sorption, is in line with the most recent international research on uranium hydro-geochemistry and contaminant transport (Prommer *et al.,* 2015 – Appendix 10.29).

The updated model used the same conservative assumptions as the previous model in initial scenarios, such as no barriers, no dilution and no lateral flows of water. Later modelling went further to include a worst case scenario whereby tailings water was allowed to release into the surrounding groundwater unabated for 200 years at a constant rate and volume.

So far the modelling has shown that updating the speciation/complexing database results in an increase in the solubility of uranium, but that including carnotite saturation, the ore mineral of the deposits proposed to be mined by Toro, places a control on maximum solubility. Importantly, when introducing reduction and therefore iron sulphide formation into the geochemical model, something that is currently observed in the shallow lake sediments directly adjacent to the proposed TSF at Millipede/Centipede and therefore within the assumed flow path of any solute release, uranium is precipitated out of solution to significantly reduced levels. In other words, a natural trap for uranium seems to already exist in the current groundwater regime (Prommer *et al.,* 2015 – Appendix 10.29).

This PHREEQC geochemical transport model will now be used by CSIRO as a base to test the effect of likely natural physical and chemical scenarios arising from implementation of this Proposal.

Toro is committed to the necessary research to further an understanding of the physical and chemical conditions within and surrounding the TSF so that a full 3D model can be established for contaminant fate transport modelling. Toro has already committed to this under condition 17(d) of the federal approval for mining at Centipede and Lake Way (EPBC 2009/5174). Under this condition, prior to the commencement of development, Toro will submit to the minister for approval a mine closure plan with a comprehensive and conservative safety assessment that includes modelling to determine the long-term risk to the public and the environment from operation of the TSF and demonstrates that the closure outcome can continue to be achieved. In consultation with the CSIRO (Prommer *et al.,* 2015 – Appendix 10.29), Toro will also undertake further field and laboratory testing to assist in the development of its Mining Proposal for assessment by the DMP.

16.3.10 Tailings Characterisation

Tailings characteristics are typically heavily influenced by the ore mineralogy, together with the physical and chemical processes used to extract the ore. The tailings characteristics have to be understood in order to establish appropriate control measures to manage the short-, medium- and long-term physical, radiological and geochemical behaviour of the tailings. Characterisation of the tailings facilitates identification of the preferred consistency, transport, deposition, placement and storage methods.

The long-term performance of the tailings is influenced by the method of deposition. It is therefore essential that the tailings characterisation process allows for the identification of key physical characteristics and the establishment of the material parameters. This facilitates estimation of the tailings settling and drying behaviour, short- and long-term densities, beach slope angles, segregation and other factors than can arise as a result of differing deposition techniques.

As the selection and refinement of the ore processing method for the Proposal has progressed, tailings samples generated at several stages have been subjected to test work to establish parameters and indications of behaviour for design purposes. This test work was conducted as an iterative process with samples subjected to a continually modified program. Each iteration was adjusted to account for information gathered from the previous round of work. The information gathered was used to develop design parameters for the tailings to be generated following ore processing by direct precipitation (DP).

The DP tailings samples consisted of ore that had undergone a bench-scale uranium extraction process intended to replicate full-scale processing. The laboratory test work program was developed to assess properties of the tailings solids including:

- Mineralogy;
- Geotechnical parameters for use in design;
- Geochemical properties of the tailings; and
- Radiological properties of the tailings.

Additional test work was conducted to assess the tailings supernatant properties including:

- Mineralogy of suspended solids;
- Suspended solids content;
- Dissolved metals content; and
- Water chemistry and pH.

Information obtained from the analysis of the tailings supernatant properties was evaluated in conjunction with the properties of the tailings solids to assist in developing an appropriate tailings management plan.

The results of the laboratory test work program identified that the inherent characteristics of the tailings would necessitate some form of intervention to achieve the tailings management objectives established for the Proposal. Without further intervention, the characteristics of the tailings arising from the extraction process exhibited specific behaviours that needed to be addressed as part of the tailings management strategy. These behaviours included:

- A short-term resistance to settling (release of supernatant water);
- A slow rate of consolidation subsequent to releasing supernatant water; and
- A subsequent low bearing capacity and shear strength that inhibited rehabilitation.

Improvement of these tailings characteristics resulted in substantial benefits in meeting tailings management and environmental objectives. These benefits included:

- Reducing the required footprint area for the TSF;
- Minimising the pond size required to manage decanted water; and
- Increased use of decanted (supernatant) water for return to the processing plant.

Consideration was given to improving the tailings characteristics through mechanical dewatering of the tailings, flocculation of the tailings near the point of discharge and a combination of these two methods. A final average tailings dry density in the range of 1.0 tonnes per cubic metre (t/m^3) to 1.2 t/m^3 has been identified as a design objective, based on desiccation and consolidation test work. Achieving the design density of tailings allows for in-pit storage of tailings that would:

- Achieve a shear strength that will allow for progressive rehabilitation; and
- Minimise the extent of any above-ground landforms required to store surplus waste materials arising from bulking during mining and processing operations.

16.3.11 Risk Assessment

Toro commissioned Knight Piésold Consulting to assess alternative tailings disposal options. This assessment confirmed that the in-pit tailings disposal option provides the lowest risk and hazard rating, consistent with current best practice (Knight Piésold Consulting, 2011).

Toro also completed a series of risk assessment workshops to identify and prioritise potential risks associated with implementation of the Proposal, including a specific risk assessment process for tailings disposal and mine closure (refer Appendix 1).

The closure risk assessment considered a range of risks (likelihood and consequence), impacts and mitigating controls associated with the long-term integrity of the TSF post-closure. This has particular relevance to the groundwater environment and the tailings cover integrity.

The analysis of likelihood and consequence was carried out after developing specific impact criteria for each environmental value or factor. Impact criteria were defined in consultation with a wide range of technical specialists and took into account current government policy and established environmental standards.

Many potentially significant risks were eliminated through design decisions taken during development of the Proposal, such as:

- Using in-pit tailings disposal into mine voids as the preferred disposal method;
- Placing all mineralised materials below the land surface at closure;
- Constructing a multi-layered tailings cover thickness of greater than 2 m to attenuate radon emanation, limit salt upwelling and divert rainwater from the surface;
- Including water barriers and an engineered clay liner in the TSF design; and
- Incorporating flood diversion structures and erosion protection into the TSF design.

The outcome indicated that of the seven events rated, none was an extreme risk, one rated as high risk and the remainder as medium risk (Appendix 1). For all events, the identified risk mitigation controls have been included in Toro's TSF design and mine closure plans and effectively reduce each of these risks to low.

In 2012, as part of Toro's commitment to best practice, Toro funded the preparation of a university thesis which studied the physical suitability of mined waste materials for use in the capillary layer of the TSF. The study concluded that inclusion of the capillary layer would 'ensure that current best practice is incorporated in Toro's tailings cover design, limiting the risk of tailings release through groundwater or evaporative forcing' (Dunne, 2012 – Appendix 10.48). The study also made recommendations for grain sorting of the materials to be used in the capillary layer. Toro will include these recommendations into the final engineering design of the mine plan.

16.4 Potential Impacts and Management

16.4.1 Tailings Design

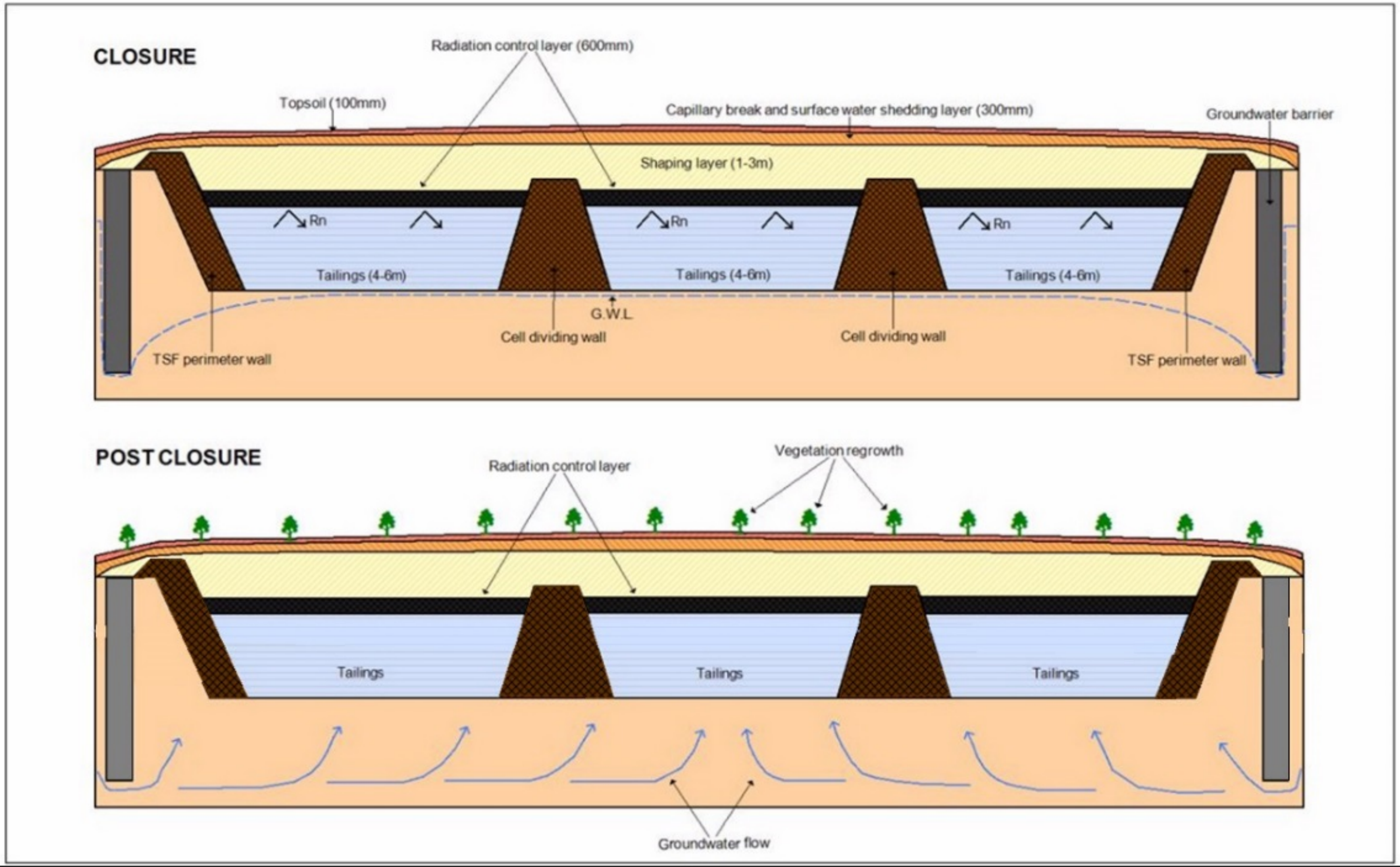
The main factor to mitigate in closure design has been identified as radon emanation from the tailings, and studies have shown that a minimum of 2 m of rock cover is required to achieve background levels of radon. The tailings cap would also be designed to minimise erosion and plant root intrusion and eliminate preferential flow patterns which could compromise the cap by infiltration and the upward movement of contaminants and salts through capillary forces.

The radiation control layer (2 m nominal thickness of sandy/gravelly waste rock and overburden) would be placed in a single pass directly over the tailings surface using low pressure dozers with the tailings still at up to 60% moisture content. The strength of the tailings plus the radiation control layer would be sufficient to form a suitable base for the rest of the cover which would comprise:

- Shaping layer: Variable thickness of non-mineralised waste rock and/or overburden to produce a profile blending with the local landform and prevent ponding;
- Capillary break layer: Coarse grained to limit upward movement of soluble tailings constituents and salts due to evaporative processes (and thereby limit plant root penetration as roots will avoid a saline environment);
- Surface shedding layer: Fine grained to reduce infiltration of rainfall into the tailings mass and sloped so that the top surface drains; this will also encourage root penetration to follow only fresh water sources; and
- Growth medium and topsoil layer: Top soil and non-mineralised overburden stripped from the pit area to promote revegetation.

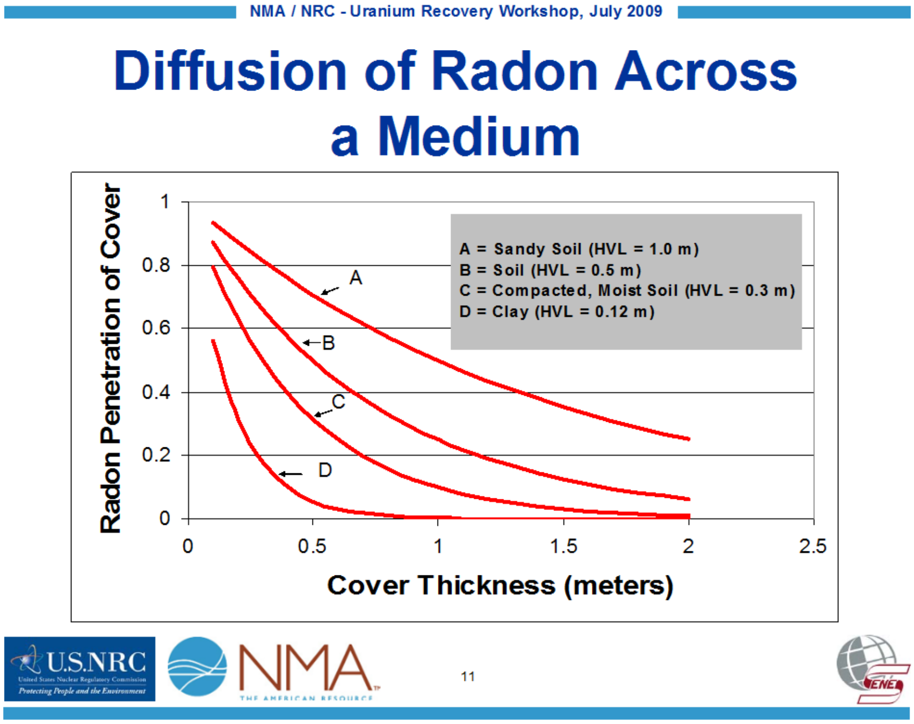
The design of the TSF, at closure and post closure, is shown schematically in Figure 16.11. It includes the low permeability clay liner in the base, water barriers around the sides of the TSF and the multi-layered cover. As the TSF would be partly below the water table, its base and perimeters would be established using low permeability clays to prevent groundwater flow into and out of the area in which the tailings were confined.

Figure 16.11: Tailings Storage Facility closure schematic



In determining a minimum 2 m tailings cap, Toro has taken into account the depth of cover required to ensure that radon emanation (and therefore the key radiation exposure pathway) is maintained to background levels over the tailings cover. This is achieved by a 'half value thickness layer' (that is the depth of material which would reduce the amount of radon being released by 50%), as shown in Figure 16.12.

Figure 16.12: Attenuation of radon gas emanation through cover media



At Millipede, using the natural material that is available, (i.e. compacted moist soils) the 2 m cover would reduce the radon transport from the tailings to about 1.5% of what it would be without a cover.

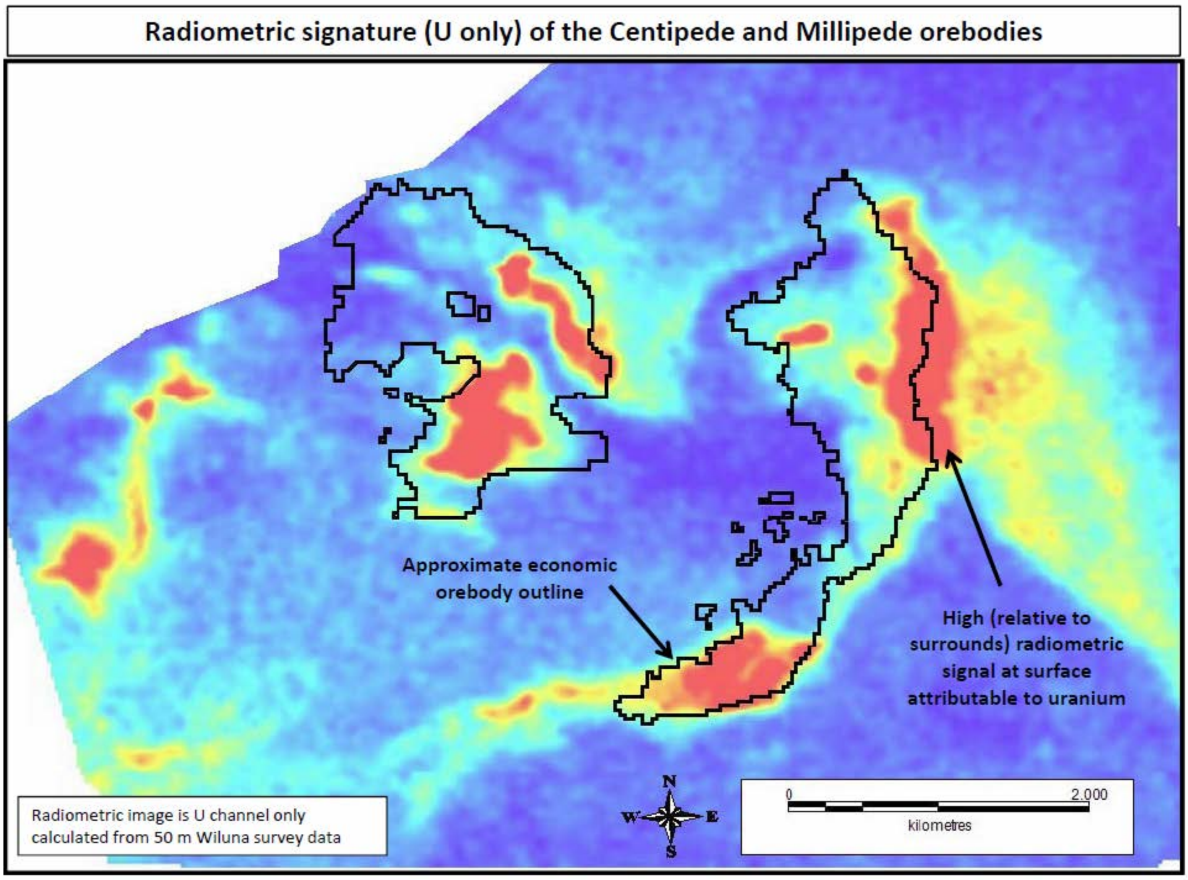
The capillary break and surface shedding layers are designed to:

- Reduce the upward movement of salts from the groundwater or tailings to the surface over long periods of time (as is seen naturally occurring at the salt lake surface); and
- Shed rainfall off the surface of the tailings such that root penetration below natural depths of 0.5 m to 1 m does not occur.

Plants would preferentially follow the fresh and more available water resource as it is diverted from the tailings and avoid the saline groundwater and the tailings themselves.

Within the broader Wiluna region, there are a number of areas, particularly in the vicinity of shallow, unmined uranium ore deposits, where radiation dose rates are higher than average Australian values, but still well within the internationally-accepted limit. At the Millipede, Centipede and Lake Way deposits, uranium has been naturally accumulating for a long period of time and therefore gamma radiation levels are already generally higher than in the surrounding areas (Toro, 2011a, Section 4.4.1). The naturally occurring radiometric signal from uranium across the region is shown in Figure 16.13.

Figure 16.13: Radiometric signature of Millipede and Centipede ore bodies



In considering the design and operation of the TSF, Toro has taken note of a range of advice about best practice. *Tailings Management*, published as part of the Leading Practice Sustainable Development Program of the Australian Government, noted:

> 'There is increasing pressure for tailings storage facility final landforms to be less visible and for progressive rehabilitation and underground or in-pit disposal to occur, where possible. In cases where mining is advanced as a series of pits, the progressive filling of mined-out pits with mining wastes should be favourably considered' (DoITR, 2007, p. 62).

A member of the Tailings Management Working Group which compiled *Tailings Management*, Dr Gavin Mudd, wrote more recently that in-pit tailings management should be considered world's best practice, especially for radioactive uranium tailings, as it has 'numerous advantages, such as inherent physical stability, low to negligible acid and metalliferous drainage risks, as well as allowing more productive use of formerly mined land' (Mudd *et al.,* 2011).

In pursuing progressive rehabilitation and the deposition of waste below ground in mine voids, Toro also took account of the strong wishes of the Traditional Owners of the Wiluna region that the mining area be restored to the original landform.

Tailings – Worst Case Scenario

Toro has also considered a worst case scenario of exposure of tailings to the environment. The scenario covered the following events:

- Erosion and scouring;
- Extreme weather events as a result of climate change;

- Permeable nature of the TSF;
- Alternative dimensions and/or configurations of the TSF; and
- Burrowing animals and the intrusion of plant root systems.

Geological Processes Including Erosion and Scouring

The Carnegie land system in which the Millipede deposit is located is a highly weathered and eroded landscape displaying deeply weathered soil profiles and little topographic relief (Toro, 2011a, Section 4.6). The Proposal is in an area of relatively low seismicity and there is no record of any significant seismic event.

In such an environment, storage of tailings below ground eliminates the potential risk of wind erosion and scouring of stored tailings. It also eliminates the risk of failure of TSF walls, as there are no engineered walls standing above ground. The design of the tailings cap and the use of deeply weathered and oxidised waste materials in its construction would further minimise accelerated weathering and erosion.

In the environment in which the Proposal would be implemented, sediment eroded from catchment rangelands is deposited, minimising erosion in the area of the mine workings where the tailings would be stored. This means that the landscape evolution forces that are at work over the TSF are depositional not erosional, thereby reducing the probability of the tailings cover being eroded.

It is also noted that even in a worst case scenario where erosion were to be a factor, the areas of the existing in situ uranium ore surrounding the TSF (i.e. the uranium ore that would be uneconomic to mine and therefore remains more radioactive than the tailings) would be exposed by erosion sooner than the tailings themselves. This is due to their more erodible nature (unconsolidated alluvium), their occurrence closer to the surface and the lack of a compacted cover. The multi-layer tailings cap, including the compacted earth layers, is much less erodible than the existing land cover.

Further to this, if the tailings were eventually exposed, the uranium is not likely to be mobilised as leach tests have shown that 95% of the uranium left in tailings is bound in the solid phase, and only 5% of the uranium is in tailings liquor and therefore available to mobilise (Table 16.3). Leach test work by the Australian Nuclear Science and Technology Organisation has also shown that uranium and other low level radionuclides do not leach readily from the tailings, even when exposed to more aggressive leaching conditions than are likely in their deposited environment (Knight Piésold Consulting, 2011).

Table 16.3: Tailings characterisation

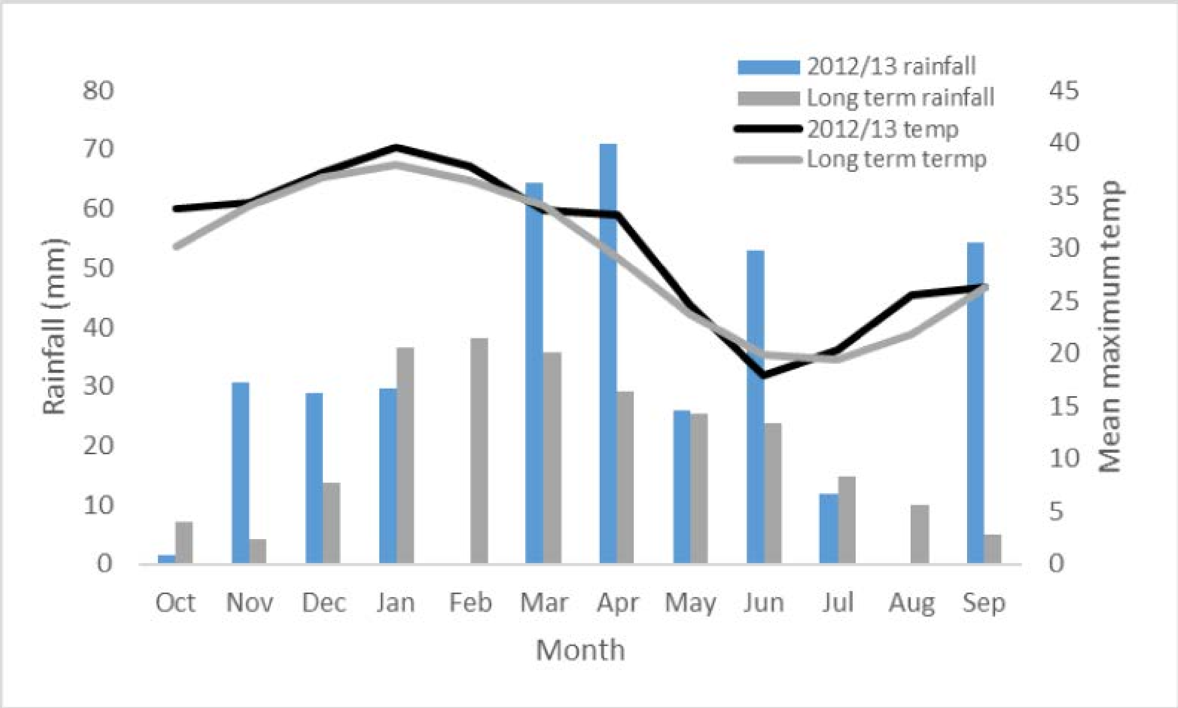
Density (t/m^3)	% solids	Permeability (m/s)	Tails Composition	
1.0–1.2	At disposal 8 %	5×10^{-9}	pH	8
			U in solids	95 %
			U remaining in liquor	5 %
			LL radionuclides in liquor	0.3 %
			Th	below detection

Source: Toro (2012)

Extreme Weather Events as a Result of Climate Change

Records from the BoM monitoring station at Wiluna do not show any pattern towards increasing rainfall in the past three decades as shown in Figure 16.14.

Figure 16.14: Rainfall records for Wiluna



Source: Bureau of Meteorology

Since rainfall records were established at Wiluna in 1893 there have been two greater than 1-in-100 year rainfall events as a result of Cyclone Trixie in February 1975 and Cyclone Bobby in February 1995 (Beesley *et al.,* 2004), as shown in Figure 16.15.

The probability of increasing frequency of extreme weather events due to climate change has been assessed by the BoM (2015). Based on the best case predictions, the climate at Wiluna continues to dry as climate change progresses. In the year 2070, annual rainfall is predicted to have dropped by 10–20% from current levels. Increased intensity and frequency of cyclonic activity is predicted for the eastern seaboard of Australia, but in the Wiluna region, changes to these events are not predicted over the current period of prediction, which is the next 50 years (BOM, 2015).

Figure 16.15: Extreme flood event rainfall records for Wiluna

Source: Bureau of Meteorology

The Permeable Nature of the TSF

The TSF has been designed to be low permeability, both in the nature of the tailings and the clay liner, multi-layered cover and water barriers that are part of the design.

Toro's test work on representative samples of process tailings has shown that the in situ tailings would have very low permeability of less than 5 x 10^{-9} m/s. For reference, the Australian Standards for low permeability liner construction require permeability at 10^{-8} m/s or 10^{-9} m/s and in many circumstances less than this figure. This means that the process tailings at Centipede would be less permeable than that required for low permeability liners of hazardous waste facilities (Knight Piésold Consulting, 2011) and given the similarity of tails composition the same conclusion is valid for tailings produced from ore mined at Millipede and Lake Maitland.

The water barriers and clay liner would also be designed to achieve a permeability of less than 1 x 10^{-8} m/s, consistent with Australian Standards (Knight Piésold Consulting, 2013a). After closure, the water table would be expected to recover to its original levels around the TSF over a prolonged period and groundwater flows return to their original configuration, i.e. towards the salt lake. Given the tailings permeability would be generally lower than the surrounding natural geology and the TSF would be designed with low permeability barriers around the sides, cap and floor of the structure, groundwater flows would tend to move preferentially through the surrounding materials rather than through the tailings mass itself (Knight Piésold Consulting, 2013a).

Alternative Dimensions and/or Configurations of the TSF

Toro has considered four potential TSF options:

- Above ground valley configuration: This was considered unsuitable as the area in which the Proposal would be developed is relatively flat, so there are no suitable sites for an above ground valley storage.
- Above ground four-sided 'above ground style' facility: The processing plant would be located close to the Millipede ore body. There are large flat areas on the site close to the plant both on Lake Way itself and on the surrounding area. While a four-sided facility would be viable, Toro believes below ground storage represents better practice.
- Below ground storage in an existing pit: In-pit storage of tailings has been used by other mining operations in Wiluna (mainly gold). There is only one existing pit in the area around Lake Way that would be suitable for disposal of tailings (an abandoned gold mine). It is approximately half way between the Millipede and Lake Way deposits. However, the pit was determined as too small to be viable as a storage facility.
- Below ground storage in the mining void: The Millipede pit would be relatively shallow and mined in compartments to enable an area of the pit to be available for tailings storage from the beginning of the plant operation. The volume of overburden plus ore removed during mining at Millipede and Centipede would be sufficient to allow all tailings to be stored below ground level, including those from the processing of ore mined from the Lake Maitland and Lake Way deposits. This option is considered to represent best practice tailings management.

To adopt this best practice in-pit option naturally limits the configuration of the TSF to the mine voids. Within this configuration, other design considerations that were required included the thickness of the tailings cover, the requirement for a low permeability liner on the base and the design of the water barriers to prevent groundwater ingress both during operations and post-closure.

In the proposed in-pit tailings configuration, mining of the voids would occur below the ore and at sufficient depth to ensure mitigation of radon by the tailings cap. The depth of the tailings disposal (that is at up to 15 m below surface) is dictated by the depth of the ore body and underlying natural clays. Mining would occur below the ore body to a depth that ensured the underlying clays were sufficiently available to form a 300 mm compacted clay base liner and there was sufficient volume to ensure that all of the tailings were able to be disposed of below the natural ground surface.

The thickness of the tailings cover is also sufficient to reduce any risk of plant root penetration and invasive species reaching the tailings. In many places the tailings cover would be over 3 m due to the shaping and re-construction of the landform, including the re-establishment of sand dunes at the margins of the mining footprint.

Burrowing Animals and the Intrusion of Plant Root Systems

No native burrowing species have been recorded in the Proposal area (Outback Ecology, 2011c – Appendix 10.52). There are only two possibilities for burrowing species in the wider region:

- The Burrowing Bettong which was previously recorded in the wider region, but is now extinct on the Western Australian mainland (Outback Ecology, 2011c – Appendix 10.52); and
- Feral rabbits which have not been found in the TSF footprint, because of the highly saline ground conditions and lack of appropriate vegetation as food supply (Outback Ecology, 2011c – Appendix 10.52).

Predicted climate trends in the Wiluna region are not conducive to any increase in the presence of burrowing species. Predicted increased temperatures and lower rainfall would result in an increased salt load at the surface, and less available fresh water resources and food supplies.

Most of the TSF footprint is currently covered by samphire flats and Toro has committed to return the landscape and habitats to as near as possible to this condition. The samphire flats are not conducive to burrowing due to the highly saline groundwater and salty deposits near to the ground surface. The balance of the TSF footprint is red sand dunes and *Melaleuca* stands (Niche Environmental Services, 2011a – Appendix 10.12), which occur around the margins of the TSF footprint as shown in Figure 16.16.

Figure 16.16: Vegetation assemblages at margins of TSF footprint

Plate 18: Samphire Flats

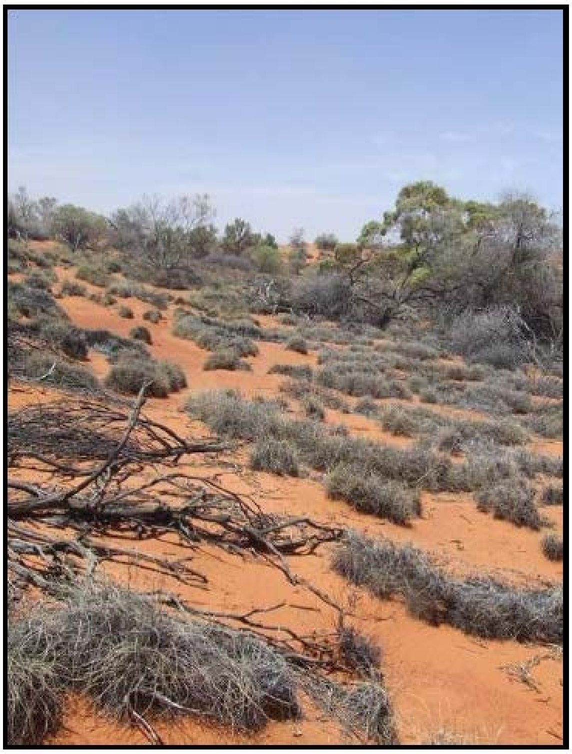


Plate 8: Red Sand Dune (Site 8)

All of these habitats have been degraded by cattle grazing and historic timber cutting over a long period, and there is little understorey or grasses to support terrestrial vertebrates. In this semi-arid environment, no presence of termites has been recorded.

As discussed, plant root penetration of the tailings cover is unlikely. Further, the root zone of the species that would be used in the rehabilitation (i.e. endemic samphire species) is estimated to be up to 0.5 m to 1 m (much less than the >2 m cover) and the tailings would be disposed of within the saline groundwater profile which is unsuitable for plant survival. Figure 16.17 shows the salt crust and the adjacent samphire flats around the margins of Lake Way due to the highly saline and shallow groundwater. This is indicative of the environment that would be recreated over the rehabilitated tailings cover.

In a worst case scenario, the topsoil and replaced overburden is extremely unlikely to be penetrated by burrowing animals or vegetation root zones. However, should this occur, the very saline nature of the groundwater (and tailings), combined with the surface shedding and capillary break layers of the tailings cover and the impermeability of the tailings themselves would stop any further penetration leading to a failure of the cover.

Figure 16.17: Salt crust along Lake Way tributary

Worst Case Scenario – Likelihood

In its mine closure planning and risk assessment, Toro has considered a range of events which in combination could lead to a worst case scenario of a tailings cover breach mobilising radionuclides into the environment. These events include:

- Upward migration of metals or radionuclides through the tailings cover system: This is highly unlikely as metals are mobilised in acid systems and the Wiluna tailings system is alkaline. Further, the radionuclide migration is also limited by the design of a multi-layered capping system which includes a radiation control layer and a capillary break layer and is of sufficient thickness to prevent radon emanation (the most likely source of exposure).
- Seepage of radionuclides into groundwater: Further studies undertaken by Toro have confirmed that local conditions and the construction of the TSF would capture and immobilise any seepage of radionuclides, especially uranium.
- Spread of contaminated waters outside containment areas: The TSF is located in a depositional and evaporative environment, adjacent to a salt pan where there are no permanent surface water bodies. Combined with the very low permeability of the tailings where water cannot penetrate or be released, the likelihood of contaminated water spreading away from the TSF and into the environment is extremely low. Even in an extreme flood event (>1-in-100 year, 72 hour duration event) waters that may cover the capped TSF would not discharge beyond the salt lake surface.
- Spread of radionuclide particulate matter: Particulate matter which may be radioactive can only be released to the environment if the tailings cover system is breached. The likelihood

of the multi-layered cover design of at least 2 m thickness being eroded to expose the tailings and enable dusting is very low. This is because the TSF is located in a flat, depositional environment where fast flowing flood waters are unlikely and soil erosion estimates are not measured due to their low rates.

The likelihood of worst case scenario outcomes have been assessed in all cases as unlikely to extremely low.

16.4.2 Closure at Lake Maitland

At Lake Maitland, the waste rock would be placed back into the pit void at similar elevations and slopes to the original topography. Backfilling would commence and continue through to the end of mining, minimising the rehandling of waste and the time the mining area was open. No tailings would be placed in the Lake Maitland pit void. Surface disturbances would be rehabilitated and no stockpiles or elevated landforms would remain. If deemed necessary, excess rock material from Millipede not considered to be ore grade would be trucked to Lake Maitland to ensure land forms at mine closure resembled, as much as practicable, land forms that existed before mining.

16.4.3 Rehabilitation and *Tecticornia* Study

Ministerial Statement No. 913 requires Toro to fund two rehabilitation projects. One will investigate the broad techniques for rehabilitating the land disturbed as a result of mining. The other will specifically look at establishing a series of techniques to allow *Tecticornia* species populations to be successfully restored. The outline of how this will be achieved will be included in a *Tecticornia* Survey and Research Plan to be developed in consultation with DPaW.

Broadly, the Survey and Research Plan will outline how scientific knowledge of *Tecticornia* is furthered. Ministerial Statement No. 913 applies only to mining at Centipede and Lake Way, but Toro would expand the scope of the plan should approval be given for mining at Millipede and Lake Maitland. The plan is currently a conceptual one that would be further discussed with regulators following completion of their assessment of proposed mining at Millipede and Lake Maitland to ensure implementation of the plan achieves the best results.

16.4.4 Closure Costing

Toro has prepared a preliminary closure cost estimate for the Proposal using the New South Wales Department of Primary Industry rehabilitation and closure cost spreadsheet (www.dpi.nsw.gov.au./Rehabilitation-Cost-Calculation-Tool-V1.7.xls). In preparing its preliminary closure cost estimate, Toro took into account volumes, areas and quantities developed by mining and other studies. Unit prices for each of the closure activities were calculated from the spreadsheet base cost and escalated for time. Recent local cost information was used where available.

In addition to the capital and operating costs arising from site decommissioning, clean up and rehabilitation, the preliminary closure cost estimate makes provision for third party management. The closure cost estimate includes a provision for post-closure environmental monitoring in all domains. An allowance of 5% of the cost of closure at each domain has been assumed for the cost of environmental monitoring in at least the first 10 years of the post-closure period. That is, if the cost to rehabilitate a domain is estimated at $1 million, a provision of $50,000 has been made for monitoring of the domain subsequent to closure.

Toro would review its closure cost provisioning prior to ground disturbing works, as part of documentation supplied in the Mining Proposal to be submitted to the DMP. The closure cost estimate would be reviewed and audited at least three-yearly, as part of Toro's regular review of its mine closure plan.

16.5 Commitments

Closure and rehabilitation at Millipede and Lake Maitland would be carried out progressively.

Toro will continue research to further its understanding of the physical and chemical conditions within and surrounding the TSF including, in consultation with the CSIRO further field and laboratory testing.

On closure of this Proposal, if approved, Toro is committed to leaving the land on which the Proposal would be implemented in as close to a pre-mining state as practicable, or in a state that fits with the post-closure land use proposed by key stakeholders, Native Title Holders and Claimants in particular.

All above ground buildings and structures would be removed and any landforms developed in the course of implementing the Proposal would be shaped and contoured to blend in with the surrounds.

Radiation in areas where mining has been undertaken would be returned to levels at or below pre-mining. Regular monitoring of bush tucker would be undertaken to ensure the bioaccumulation of radioactive elements in food sources was not occurring.

16.6 Outcome

Implementation of the Mine Closure and Rehabilitation Plan would ensure that Project infrastructure is decommissioned and the land rehabilitated in an ecologically sustainable manner.

17 OFFSETS

17.1 Objective

To counterbalance any significant residual environmental impacts or uncertainty through the application of offsets.

17.2 Relevant Legislation and Policy

The Government of Western Australia has an offsets policy that seeks to protect and conserve environmental and biodiversity values for present and future generations. The use of environmental offsets has been developed to complement proper environmental management and to compensate for residual environmental impacts. It is designed to achieve long-term outcomes, building upon existing conservation programs and initiatives (Government of Western Australia, 2011).

Environmental offsets will take account of, and contribute towards, broader state government conservation objectives through existing programs, policies, initiatives and strategic funds. This includes the establishment and ongoing management of national parks, reserves and other conservation estate.

This policy seeks to ensure that environmental offsets are applied in specified circumstances in a transparent manner to engender certainty and predictability, while acknowledging that there are some environmental values that are not readily replaceable. It serves as an overarching framework to underpin environmental offset assessment and decision-making in Western Australia. The EP Act defines environmental value as:

> 'A beneficial use or ecosystem health indicator. A beneficial use is a use of the environment which is conducive to public benefit, public amenity, public safety, public health or aesthetic enjoyment and which requires protection from the effects of emissions or environmental harm. An ecosystem health indicator is a condition of the ecosystem which is relevant to the maintenance of ecological structure, ecological function or ecological process and which requires protection from the effects of emissions or environmental harm'.

Offsets are a component in the state government's broader approach to the environment. Environmental offsets are to be required only after due consideration of avoidance and mitigation measures.

In this context, the state's assessment and decision-making processes in relation to the use of environmental offsets are underpinned by these principles:

- Environmental offsets will only be considered after avoidance and mitigation options have been pursued;
- Environmental offsets are not suitable for all projects;
- Environmental offsets will be cost-effective, as well as relevant and proportionate to the significance of the environmental value being protected;
- Environmental offsets will be based on sound environmental information and knowledge;
- Environmental offsets will be applied in a framework of adaptive management; and
- Environmental offsets will be focussed on longer term strategic outcomes.

Environmental offsets will be designed to be enduring, enforceable and deliver long-term strategic outcomes. A flexible approach to the security, management, monitoring and audit of offsets will be adopted to ensure that anticipated environmental outcomes are realised.

Responsibility to nominated agencies for monitoring, auditing and compliance with set conditions is ascribed in the EP Act and other state legislation. All environmental offsets that are included as part of a statutory approval will identify the agency responsible for monitoring its implementation, ongoing auditing and legislative basis.

In fulfilling its responsibility under the EP Act to assess significant proposals, the EPA can recommend to the Minister for Environment whether a proposal can proceed and, if so, under what conditions. Such conditions may include offsets if a significant residual environmental impact remains after avoidance and mitigation measures have been applied in the implementation of a proposal.

Where proposals impact on MNES listed under the EPBC Act, the federal government may also require environmental offsets.

17.3 Proponent Studies and Investigations

As a result of the assessment of Toro's proposal for mining at Centipede and Lake Way, and on the recommendation of the EPA, the Minister for Environment applied an offset in his Ministerial Decision as a condition of approval of that proposal (EPA Report 1437; Ministerial Statement No. 913).

This offset requires Toro to implement a survey and research plan with a minimum total monetary value of $900,000 to conserve and improve scientific knowledge of *Tecticornia* species. Implementation of the *Tecticornia* Survey and Research Plan is expected to deliver outcomes that lead to the successful conservation and rehabilitation of *Tecticornia* species at Centipede and Lake Way and Toro would extend the plan to mining at Millipede and Lake Maitland should this Proposal be approved.

Toro has undertaken significant studies into the impacts that this Proposal may have on the environment. The outcomes of these studies have been reported on in this PER. When viewed in both a local and regional context, Toro does not believe any impacts have been identified that cannot be effectively mitigated through avoidance, minimisation and rehabilitation such that there would be no material residual impact on the environment from implementation and subsequent closure of the Proposal.

17.4 Avoidance

The clearing of vegetation and calcrete to implement the Proposal cannot be avoided. However, the vegetation to be cleared is well represented in the wider region and the amount of each vegetation type to be cleared is low as discussed in Section 9.

Calcrete hosts the uranium ore and has to be removed to allow the ore to be processed. The mineralised extent of the calcrete is associated with the occurrence of the salt lake. Calcrete is also a host for fauna habitat. However, the amount of habitat to be removed is low compared with the available habitat in the calcrete systems across Lake Way and Lake Maitland.

17.5 Minimisation

Lake Maitland was proposed by its previous owner as a stand-alone mine to target mineralisation inside a 200 ppm cut-off range. That proposal would have had its own processing plant and other infrastructure which would have required about 1500 ha of clearing by itself.

This Proposal, to integrate Lake Maitland into the Wiluna Uranium Project with one central processing plant, reduces the need for clearing by at least 750 ha.

As Toro undertakes engineering studies for mining at Millipede and Lake Maitland, it will give further consideration to the location of infrastructure within the development envelopes to seek to further reduce vegetation clearing.

17.6 Rehabilitation

Toro has developed a plan for mine closure and rehabilitation consistent with best practice, involving progressive rehabilitation and the storage of tailings in mined-out pit voids. This method avoids leaving artificial above ground structures at closure.

17.7 Clearing Principles

To assess whether implementation of the Proposal would have any residual impacts, the 10 clearing principles listed in the EP Act were considered. An assessment of the application of each principle is given below:

Native vegetation should not be cleared if it compromises a high level of biodiversity.

The land to be cleared under this Proposal has been assessed for vegetation type and flora and fauna values. (Ecologia, 2015a – Appendix 10.36; Niche Environmental Services, 2014 - Appendix 10.13; Outback Ecology, 2001). In a regional context the land to be disturbed shows no high levels of biodiversity. Accordingly, clearing associated with implementation of the Proposal would not be at variance with this principle.

Native vegetation should not be cleared if it compromises the whole, or part of, or is necessary for the maintenance of a significant habitat for flora indigenous to Western Australia

The flora which would be cleared is well represented in the wider region. During the assessment of mining at Centipede and Lake Way (EPA Assessment 1819, EPBC 2009/5174), *Tecticornia* species were collected that could not be identified, meaning the impact of the clearing of those species could not be quantified. Toro has undertaken further sampling, incorporating recommendations made by Actis (2012 - Appendix 10.61) and has given all samples collected to the Western Australian Herbarium for identification (Ecologia, 2015e – Appendix 10.7).

These surveys identified up to seven novel species across the Millipede and Lake Maitland deposits. As discussed in Section 9, the distribution of these species was mapped and it was found that they were present across both Lake Way and Lake Maitland, inside and outside proposed disturbance areas.

For this reason, Toro does not consider the clearing to be undertaken in implementation of this Proposal to be at variance with the clearing principle.

Native vegetation should not be cleared if it includes, or is necessary for the continued existence of rare flora.

As discussed in Section 9, no rare flora have been identified in the Project area. While the taxonomy of some *Tecticornia* specimens is yet to be resolved, mapping of the locations in which these specimens were taken showed they occurred inside and outside the Project area.

Native vegetation should not be cleared if it compromises the whole, or part of, or is necessary for the maintenance of a Threatened Ecological Community.

Fauna surveys have not identified any Threatened Ecological Communities occurring within or in the vicinity of the Project area.

Native vegetation should not be cleared if it is significant as a remnant of native vegetation in an area that has been extensively cleared.

Vegetation across the Project area remains relatively intact and has not been extensively cleared. The vegetation to be cleared to permit implementation of this Proposal is well represented in the wider region and mostly intact.

Native vegetation should not be cleared if it is growing in, or in association with a watercourse or wetland.

Across both Lake Way and Lake Maitland vegetation would need to be cleared that is growing either inside the lake itself (at Lake Maitland) or on the lake playa and edges of ephemeral creeks (Lake Way). In both locations the vegetation to be cleared is primarily *Tecticornia* species which are found in regions of high groundwater salinity.

The clearing of this vegetation is likely to be at variance with the principle and so has been considered in the Environmental Offsets Template (Section 17.8).

Native vegetation should not be cleared if clearing of the vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation area.

The closest conservation area to the Proposal is Wanjarri Reserve, 40 km to the south-west of Lake Maitland. The clearing associated with this Proposal would have no impact on the conservation values of the Wanjarri Reserve.

Native vegetation should not be cleared if the clearing of vegetation is likely to cause appreciable land degradation.

The land across the Project area has been grazed for over a century and is still under active pasture. The vegetation condition in the region has been described as good to very good (Niche Environmental Services, 2014 – Appendix 10.13). As all vegetation types in the Project area are well represented in the local region and greater bioregion, it is unlikely that any significant land degradation would occur with the implementation of the Proposal.

Native vegetation should not be cleared if the clearing is likely to cause deterioration in the quality of surface or underground water.

Surface water flows in the Project area occur only once local soils are saturated after periods of heavy rain. In the event of such falls, surface waters would be directed around the mining areas and flows and quality would not be affected. Groundwater within the Project area is hypersaline and there would be no reduction in groundwater quality.

Native vegetation should not be cleared if the clearing is likely to cause, or exacerbate, the incidence or intensity of flooding.

There are no permanent sources of surface water in the region. Lake Way forms a regional sink for run-off and groundwater. It is only after periods of cyclonic rain that the salt lakes in the region fill with water. For most of the time, they are dry. There is no potential for clearing required for implementation of the Proposal to lead to an increase in local flooding.

17.8 Offsets Template

The WA Environmental Offsets Guidelines contain a template to be used to assess the need for offsets where clearing is found to be at variance with any of the ten principles. Toro has identified that the clearing of *Tecticornia* vegetation associated with the Lake Way and Lake Maitland systems could be at variance with the principle relating to native vegetation growing in association with a water course or wetland. For this reason, the Environmental Offset Template was completed.

The template is shown in Figure 17.1. *Tecticornia* species are poorly resolved taxonomically and little is known about their ecological requirements. During the previous assessment for the Wiluna Project (EPA Assessment 1819) Toro was given a condition to implement a *Tecticornia* Survey and Research Plan to further classify the *Tecticornia* species that grow around Lake Way, so that their conservation significance can be determined. The research component of the plan was designed so that the rehabilitation requirements of the species could be identified and the optimum conditions for the return of species, communities and populations could be determined.

The uncertainty surrounding *Tecticornia* species has been somewhat resolved by the additional work undertaken by Toro, Ecologia and the Western Australian Herbarium to inform this assessment of the proposed extension to the Wiluna Project. Although some potentially new species have been identified, the mapping of these species suggests that their distribution is widespread and not limited to direct impact areas associated with the Proposal. This field study, combined with the *Tecticornia* Survey and Research Plan that would be implemented prior to the commencement this Proposal should it be approved, will further define the extents of various species, and will also identify methods to rehabilitate disturbed areas. The survey and research plan is likely to be ongoing in some form throughout the life of the Proposal to provide information for continuous testing and refining until an effective rehabilitation method is developed. It is therefore considered unlikely that there would be any residual impacts on *Tecticornia* species, communities and populations post mine closure.

At the southern end of the Millipede and Centipede tenements, Abercromby Creek flows into Lake Way. The northern edge of the creek is the border of the uranium mineralisation and so vegetation across this area would need to be removed. As the local groundwater is highly saline (>100,000 mg/L TDS), the main vegetation that would be cleared is *Tecticornia*. To rehabilitate this area, the outcomes of the survey and research plan would be implemented. Toro believes that *Tecticornia* associated with Abercromby Creek would be rehabilitated in the same manner as the *Tecticornia* associated with the lakes and the lake playas and that there would be no residual impacts on either described or currently undescribed species.

17.9 Conclusion

Environmental offsets are not appropriate for all projects and in all circumstances (EPA, 2011). Toro has concluded that this Proposal may be at variance with clearing principle six. However, the proposed *Tecticornia* Survey and Research Plan would allow any impacts associated with this clearing to be mitigated during rehabilitation and decommissioning of the Proposal. Otherwise, Toro has concluded that this Proposal is not at variance with any of the clearing principles listed in the EP Act. All impacts to the environment can be managed through avoidance, minimisation and rehabilitation and there would be no residual impacts.

17.10 Commitments

As an already agreed offset, Toro would implement a Survey and Research Plan to further the knowledge of *Tecticornia* species. This was a requirement of Ministerial Statement No. 913 for the approval of mining at Centipede and Lake Way. Should the extention to the Wiluna Uranium Project be approved, Toro would further develop the plan to cover the impacts of mining at Millipede and Lake Maitland. This would be done in consultation with DPaW and include research into the most appropriate survey methodology for *Tecticornia* sp. and vegetation communities and research into the taxonomy of relevant species complexes to allow future survey and impact assessment. The outcomes of the research would also be applied to conservation of *Tecticornia* and rehabilitation of any *Tecticornia* vegetation communities disturbed by implementation of this Proposal

The Commonwealth Government may also have offset requirements pursuant to the EPBC Act. Toro will undertake further consultation with the Commonwealth Department of Environment to ensure that any Commonwealth offset requirements in relation to the Proposal are addressed.

17.11 Outcome

Any impacts associated with implementation and subsequent closure of the Proposal would be avoided, minimised or rehabilitated, so that there were no material residual impacts required to be counterbalanced by the application of offsets.

Figure 17.1: Environmental Offsets Template

Existing environment/impact	*Mitigation*			*Significant Residual Impact*	*Offset calculation methodology*				
	Avoid and minimise	*Rehabilitation type*	*Likely Rehab Success*		*Type*	*Risk*	*Likely offset success*	*Time lag*	*Offset Quantific-ation*
Clearing of Native Vegetation - the Proposal would result in the clearing of up to 1581.8 ha.	Key infrastructure such as the processing plant would be shared between Millipede and Lake Maitland reducing the overall need for clearing. Mining areas have been well defined and Toro would use efficient surface mining techniques to ensure only target areas need to be disturbed. Monitoring would commence immediately areas have been rehabilitated to initially consider issues such as	Progressive rehabilitation would be practised over the life of the Project. Rehabilitation in similar environments around the region has shown that off the lake rehabilitation of the disturbances is highly effective. Rehabilitation of the mined areas would return contours to the pre-mining landscape to the extent practicable. Any artificial above-ground structures created by the mining operation would be removed.	In the areas proposed for mining and infrastructure, Toro has undertaken rehabilitation of previously excavated costeans and land cleared for drilling which has been successful.	No					

	local gamma radiation levels, the depth of topsoil and the adequacy of topsoil coverage, to assess whether the ground has been physically returned to a condition suitable for the recovery of the ecosystem. Annual surveys would commence one-year post rehabilitation to assess whether species are returning to disturbed areas. Surveys would assess diversity and abundance, the presence of weeds and evidence of grazing. Ongoing monitoring would assess how the composition of the ecosystem is changing and analog sites in similar vegetation types and ecosystems would to used to gauge how								

	rehabilitation was progressing.								
Clearing of *Tecticornia* vegetation on the edge of Lake Way and at Lake Maitland	As much infrastructure as possible would be located outside the *Tecticornia* habitat. Toro has undertaken significant studies to assess populations of *Tecticornia* around the lake. This has identified that the spread of species, even novel species, is widespread.	Toro would undertake progressive rehabilitation. A survey and research plan would be implemented by Toro prior to the commencement of the operation to identify ecophysiological requirements of *Tecticornia* species and to identify methods to rehabilitate the disturbed areas.	Rehabilitation trials would be ongoing throughout the life of the Project and would feed into the Project's closure plan. It is likely that the survey and research plan would identify the best methods to ensure maximum rehabilitation success due to the size and nature of the plan.	No					
Clearing of vegetation located along Abercromby Creek that flows into Lake Way	The Centipede deposit is bound on the south eastern side by Abercromby Creek. The northern edge of the creek represents the boundary of the deposit and would be cleared for mining. The southern side of the creek would remain undisturbed.	*Tecticornia* are the prime species in this area. The *Tecticornia* Survey and Research Plan would address how to rehabilitate this area.	Toro has undertaken rehabilitation trials across two previously excavated costeans using seeding and various land treatments. These trials are continuing but it is evidence already that vegetation communities are recovering. This is in addition to the work Toro would fund and support	No					

			under the *Tecticornia* Survey and Research Plan to re-establish vegetation communities and conservation significant taxa in disturbed areas.						
Clearing to install the haul road, borefields and other infrastructure	To the extent practicable, Toro would use existing established tracks for the haul road and other access routes for the Project. A rule of no unauthorised driving off established road and access tracks would be strictly applied. Access to areas of native vegetation near the accommodation villages and other Project areas would be restricted to minimise the risk of unauthorised disturbance.	Areas no longer required during operations would be progressively rehabilitated and monitored. Where practicable, seed would be collected from plants prior to removal to ensure that the same genotype and correct taxa were rehabilitated into the area. Seed collected would be stored in air tight (but not plastic) containers to ensure their viability.	Toro has proposed to Traditional Owners that they become involved in rehabilitation work including through monitoring and the provision to Toro on a commercial basis of services required for rehabilitation including on-going collection and storage of topsoil and seeds, seed germination and banking. The incorporation of this local knowledge and Toro's proposal for progressive re-habilitation would enhance the likelihood of success	No					
Clearing of fauna habitat	All significant fauna habitat would be	Progressive with contours returned to pre-mining	Regular monitoring would be undertaken to	No					

	identified, mapped and demarcated on-site. No off-road driving unless in the case of an emergency or authorised by the Environmental Officer. Retention of mature/large trees where practicable. Progressive clearing of vegetation to allow fauna to disperse to other suitable areas. Retention of habitat corridor and/or linkages wherever possible to allow fauna to move between remaining habitat. Installation of fauna egress points at all open voids and ponds. Retention of fauna burrows where possible.	landscape to the extent practicable. Any artificial above-ground structure created by the mining operation would be removed.	support the Mine Closure and Rehabilitation Plan which would include fauna surveys to assess whether fauna is returning to disturbed areas.						

18 OTHER FACTORS

In addition to the preliminary key environmental factors identified by the EPA for this assessment, the ESD also required the factors of Amenity (Noise) and Air Quality to be concisely described and discussed in the PER.

18.1 Noise

The Project area has a rural character with no nearby localised noise sources. At Millipede, the nearest industrial noise source to Toro's proposed operations is the Jundee Gold Mine, located approximately 75 km north-east of the Millipede deposit and about 45 km north-east of the Wiluna town centre. The Wiluna airport, located approximately 25 km north-west of Millipede, contributes intermittent noise.

At Lake Maitland, background noise levels are low, based on the remote nature of the site and the current pastoral use of the area. The nearest industrial noise source is the Mt Keith nickel mine, approximately 50 km west of Lake Maitland. Monitoring has shown that existing ambient noise sources are specifically environmental in nature, such as insects, birds and wind.

The development and operation of the Proposal would result in an increase in ambient noise. Mining would occur continuously (on a 24 hour, 7 days per week operational basis). Based on the findings of an environmental noise assessment carried out by Lloyd George Acoustics (2011), the most significant sources of noise from Toro's proposed operations would be operation of Vermeer surface miners (133 dB(A) per unit) and CAT 777 haul-packs (123 dB(A) per unit). Other potential sources of noise and/or vibration would include drilling, vehicle movements, crushing and conveying of ore, and rock dumping and grading of surface materials, and at Millipede only, operation of the processing plant.

The key control on impacts from noise is the *Environmental Protection (Noise) Regulations 1997* (WA) ('the Noise Regulations'). No Commonwealth legislation is applicable to the Proposal in relation to noise.

The Western Australian Noise Regulations require any noise emitted from a premises to comply with 'assigned noise levels', when received at any other premises. As there are no other noise producing industries in the immediate vicinity of mining at Millipede and Lake Maitland, the noise from the Proposal would not significantly contribute to an existing level of noise which exceeds the 'assigned level' prescribed standard under the Environmental Protection (Noise) Regulations 1997 (Lloyd George Acoustics, 2011).

The nearest sensitive receptors to the Proposal are:

- Wiluna town;
- Bondini reserve;
- Ngangganawili community;
- Lake Way pastoral station;
- Millbillillie pastoral station;
- Barwidgee pastoral station; and
- Proposed Toro accommodation villages to support mining at Millipede and Lake Maitland.

All construction and mining activities associated with the Proposal would be at least 4000 m from the nearest receptor.

The EPA's Objective for Amenity (Noise) is to ensure that impacts are reduced to as low as reasonably practicable.

Potential Impacts

Noise has the potential to disrupt ecosystem function, primarily through the displacement of local fauna. Loud construction and operational activities would lead to an increase in ambient noise levels and local fauna may migrate to a suitable habitat away from the noise source. The increase in ambient noise levels may also impact on established foraging grounds.

Responses to noise differ between animal species, ranging from no response to interruptions in feeding and resting behaviour, to complete abandonment of an area. Noise may lead to reduced population densities in small mammals, nest failure and decreased population densities in birds (Slabbekoorn and Ripmeester, 2008) and abandonment of roost sites and a reduced hunting efficiency in bats due to disturbance of their echolocation systems. Constant high levels of noise may interfere with communication and is known as acoustic interference (Parris and Schneider, 2009).

Impact Assessment

The results of noise modelling conducted for the Proposal show that noise emissions from the proposed mining and processing are predicted to comply with the assigned levels *Environmental Protection (Noise) Regulations 1997* at all noise sensitive receptors (Lloyd George Acoustics, 2011; Golder Associates, 2011g).

Noise emissions from individual items of machinery have been identified as low. Modelling (Lloyd George Acoustics, 2011; Golder Associates, 2011g) indicates that the noise at the sensitive receptors from individual items of plant is very low, and that any annoying noise characteristics, in particular tonality, would not be detectible and would not result in any discernible impact to the nearest receptors.

It is possible that some disruption to fauna would occur as a result of noise from construction and mining activities. However, these effects are expected to be local in scale and not to have long-term detrimental impacts on fauna. It is expected that most species would become acclimatised to changes in noise levels during both construction and operation of the Proposal.

Impact Management

Toro would implement a Noise Management Plan to include actions to minimise potential impacts to fauna with all vehicles, plant and machinery to be operated within appropriate noise standards and relevant guidelines.

Based on the modelling results, noise associated with the Proposal would comply with relevant statutory requirements and standards. Toro would adopt the following strategies to reduce potential noise impacts on employees, local fauna and other sensitive receptors:

- Using the quietest available vehicles, plant and machinery equipment and, if necessary, the use of sound buffering techniques;
- Incorporating noise minimisation considerations into the design and layout of the mine sites to reduce the impact on the nearest sensitive receptors;
- Directing principal noise sources (e.g. exhausts) away from noise sensitive places as far as possible;
- All vehicles, plant and machinery to be maintained and regularly serviced according to manufacturer's specifications; and
- Minimising the use of warning devices to within operational health and safety constraints.

Noise levels would be monitored periodically as would potential impacts to fauna through specific fauna surveys. If complaints were received in relation to operational noise, they would be investigated promptly and corrective actions would be implemented as required. Any complaints received would be documented in a register, along with information on actions taken to resolve the matter.

Predicted Outcomes

Given the remote setting of the proposed operations, the distance to the nearest sensitive receptors, and the generally low levels of noise associated with the proposed activities, it is predicted noise impacts to amenity would be reduced to as low as reasonably practicable and comply with regulatory limits. Any adverse impacts on ecosystem function as a result of local movements of fauna in response to noise are predicted to be minor and temporary.

18.2 Air Quality and Atmospheric Gases

The information in this section of the PER in relation to air quality supplements that in Section 14 which deals specifically with the composition and concentrations of radionuclides in naturally occurring dust.

The main influences on background air quality in the Project area are environmental dust and occasional emissions of nitrogen oxides, carbon monoxide and particulates from bush fires. Dust storms are characteristic of the Northern Goldfields region (Figure 18.1) and may give rise to high levels of ambient dust lasting from several minutes to several hours. However, typical background particulate concentrations are likely to be less than about 16 µg/m^3 for fine particulate matter (PM_{10}) and less than 32 µg/m^3 for total suspended particulates (Air Assessments, 2011).

Figure 18.1: Dust storm at Lake Way, 25 November 2010

Note: This event was described by the Bureau of Meteorology as a 'slight to moderate' dust storm.

The value of 16 µg/m^3 total suspended particulates is estimated from a six-month program of continuous monitoring conducted by Toro at Wiluna in 2007–2008 and corresponds to the estimated 70th percentile TSP concentration. More information on background concentrations of TSP and PM_{10} particulates is presented in Air Assessments (2011).

Previous mining operations in the Wiluna region have contributed at a very local scale to airborne emissions of particulates (including the metals or salts associated with the particulates) and to emissions of nitrogen and sulphur oxides from burning of fossil fuels. The effects of local industry on average background concentrations of carbon monoxide, ozone, nitrogen oxides and sulphur dioxide are negligible.

Toro has conducted real time dust monitoring (of PM_{10} dust) using a tapered element oscillating microbalance (TEOM). Summarised results are provided in Table 18.1.

Table 18.1: Monthly dust measurements at Wiluna (TEOM-PM_{10})

Dates	PM_{10} Dust Concentration, µg/m^3						
	Average	Max	Min	Median	Std Deviation	90th Percentile	99th Percentile
Sept 2007	10.4	112	6.3	8.3	9.8	15.4	60.6
Oct 2007	12.8	346	4.7	10.1	15.8	21.9	59.8
Nov 2007	12.4	448	5.6	9.7	12.6	22.0	43.5
Dec 2007	12.8	351	5.7	10.9	10.7	19.7	45.8
Jan 2008	21.2	1367	11.1	13.6	64.2	26.9	165.9
Feb 2008	11.9	186	5.2	10.2	9.8	18.5	50.0
Mar 2008	17.6	728	9.2	15.0	18.3	27.6	69.1

At Lake Maitland, the main sources of anthropogenic dust include:

- Motor vehicle movements;
- Mining activities; and
- Pastoral activities.

The main natural sources of dust include:

- Wind erosion; and
- Scrub fires initiated by lightning strikes.

Historically, regional industry has been heavily focused on mining, with some diesel power generation at mining facilities and pastoral stations. Fine particulate matter from combustion engines is not produced in great quantities. The predominant source of particulate matter is wind eroded crustal dust. Larger eroded dust particles tend to settle out, leaving finer particles of less than 10 µm to represent the majority of dust entrained in the atmosphere over long distances.

The potential air quality impacts from mining at Lake Maitland are anticipated to be principally associated with particulate matter emissions to air. Consequently, ambient air quality monitoring has been conducted for the following size fractions:

- Total suspended particulate matter (TSP) (nominally particles with an equivalent aerodynamic diameter less than 50 µm);
- Particulate matter with an equivalent aerodynamic diameter less than 10 µm (PM_{10});
- Particulate matter with an equivalent aerodynamic diameter less than 2.5 µm ($PM_{2.5}$); and
- Insoluble solids deposition.

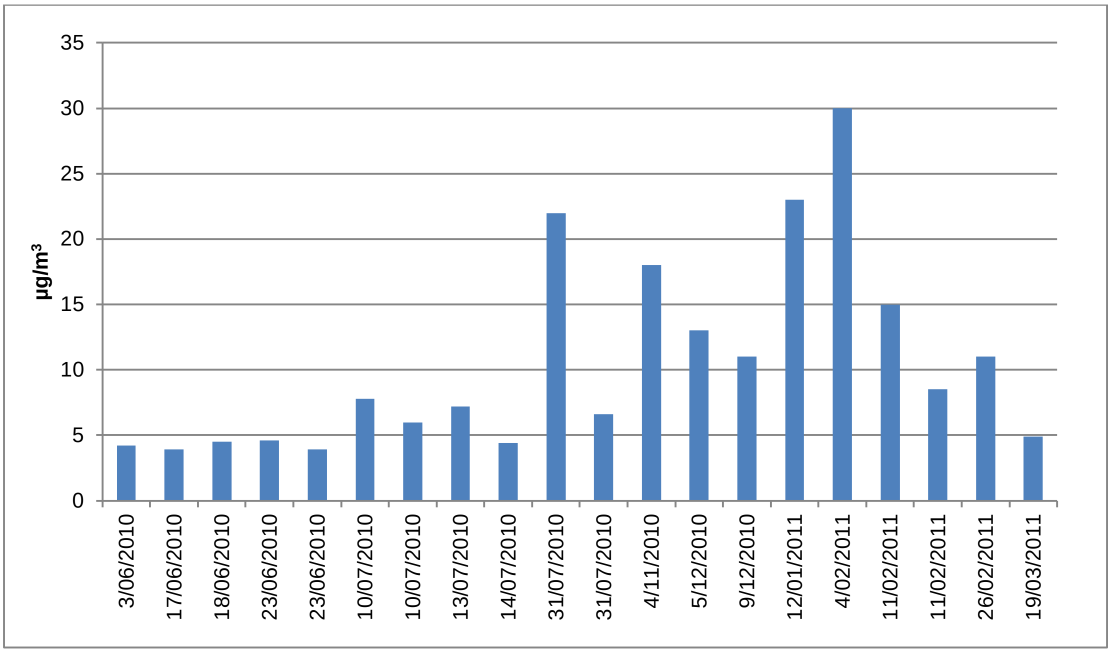
For a 10 month period, dust deposit gauges (insoluble solids) and dichotomous samplers (PM_{10} and $PM_{2.5}$) were located at Barwidgee Pastoral Station and an exploration camp sited near where mining would occur.

TSP monitoring using high volume air samplers has been conducted at 13 locations. These locations coincided with radiation baseline monitoring, with samples collected primarily to determine alpha radioactivity through analysis of TSP filter papers. Consequently, the samples were collected over extended sample periods, exceeding 24 hours. Sampling was conducted in accordance with the method described by Australian Standard AS/NZS 3580.9.3 *Determination of Suspended Particulate*

Matter —Total Suspended Particulate Matter (TSP)—High Volume Sampler Gravimetric Method. The maximum measured result from this program was transformed to a 24 hour average and used to represent the background TSP concentration.

The TSP results are displayed graphically in Figure 18.2.

Figure 18.2: Background air quality: TSP monitoring results – Lake Maitland



PM_{10} and $PM_{2.5}$ sampling was conducted at Barwidgee Station and the exploration camp while it functioned. The results are in Figure 18.3 (PM_{10}) and Figure 18.4 ($PM_{2.5}$).

Figure 18.3: Background air quality: PM_{10} monitoring results – Lake Maitland

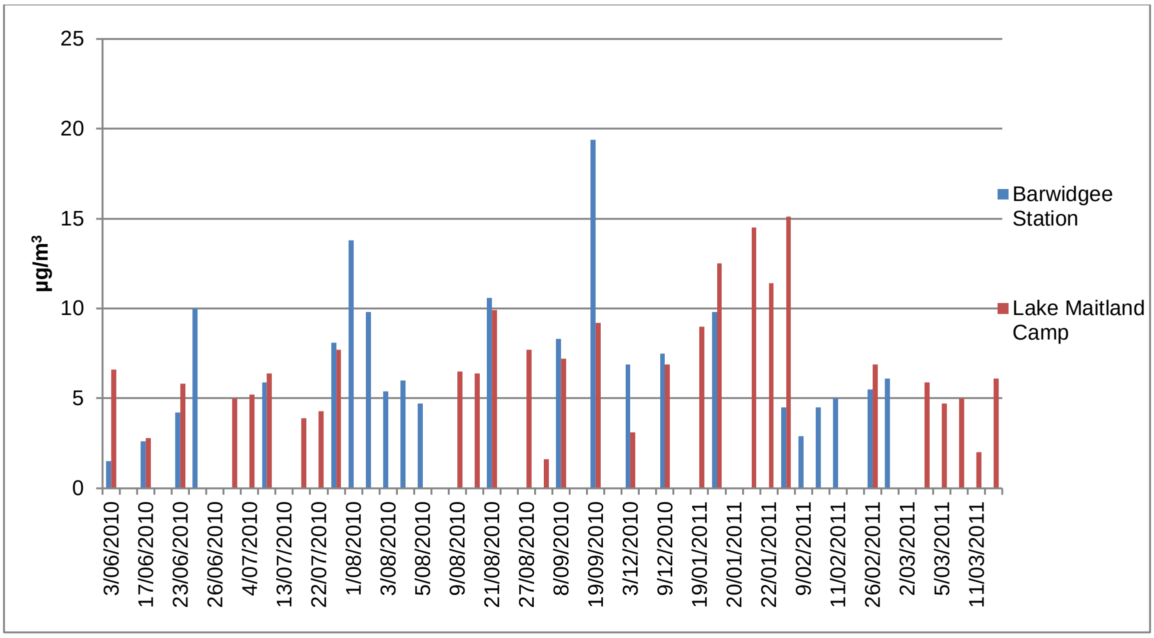
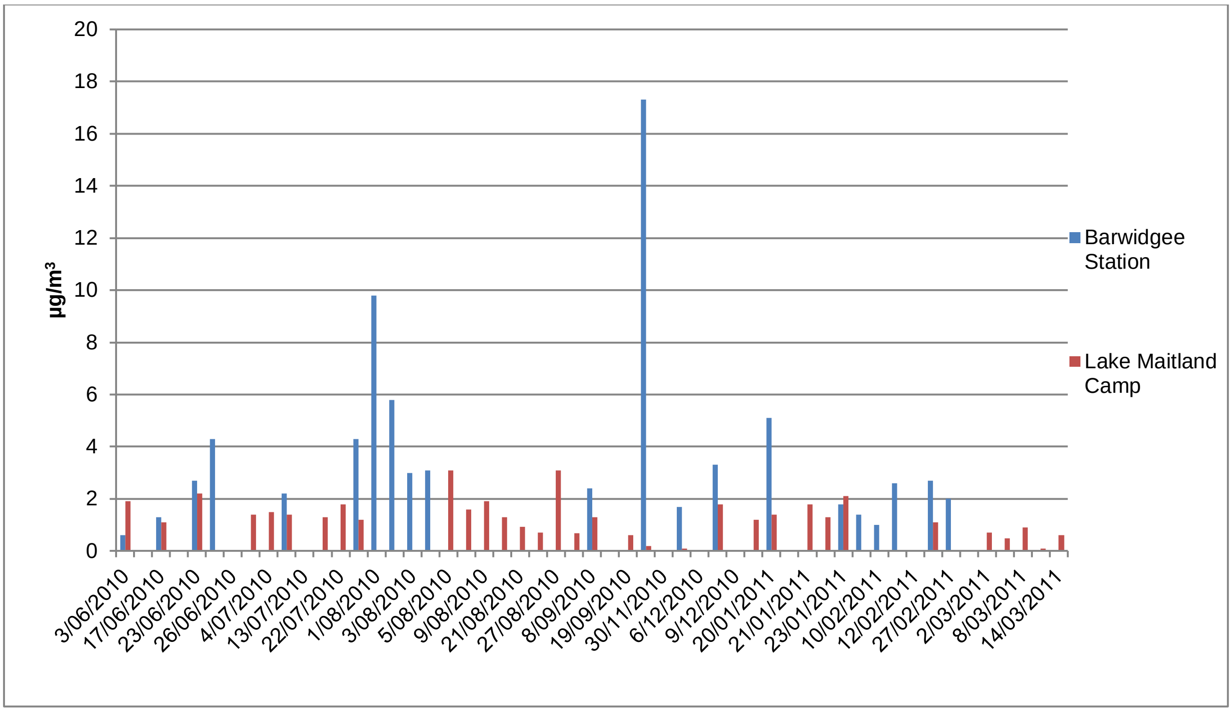


Figure 18.4: Background air quality: $PM_{2.5}$ monitoring results – Lake Maitland



The monitoring illustrated the relatively low levels of background particulate matter at Lake Maitland. The results at the exploration camp during November 2010 were impacted by increased activity due to the conduct of a test pit program during that period. Therefore, the 24 hour average background PM_{10} and $PM_{2.5}$ concentrations are based on the maximum measured result, excluding November 2010.

$PM_{2.5}$ was also assessed against an annual average criterion. The background concentration assumed for the $PM_{2.5}$ annual average impact assessment was the average of all monitoring results, excluding November 2010.

Dust deposition monitoring was conducted at Barwidgee Station and while the exploration camp functioned. The sampling and analysis was conducted in accordance with the method described by AS/NZS 3580.10.1 *Methods for Sampling and Analysis of Ambient Air - Determination of Particulate Matter - Deposited Matter - Gravimetric Method*. Samples were analysed for insoluble solids, with the results ranging between 1.3 g/m^2/month and 1.9 g/m^2/month. Although the dataset is limited, the results are in the range suggested by the Victorian Department of Health for dust deposition in rural zones, 0.4 g/m^2/month to 2.0 g/m^2/month (Department of Health, 1966).

The background concentration of particulate metals was determined through analysis of TSP filter papers from the alpha radioactivity monitoring program. Six filters, representing the highest particulate matter loading, were analysed for 21 metals.

The analytical results indicated that all particulate metals were less than the analytical method limit of detection, including radionuclides. Therefore, no background concentration was included for any of the particulate metals targeted within the air quality impact assessment.

The EPA's Objective for Air Quality and Atmospheric Gases is to maintain air quality for the protection of the environment and human health and amenity, and to minimise the emission of greenhouse and other atmospheric gases through the application of best practice.

Potential Impacts

The key pollutants of concern associated with uranium mining and processing are:

- Particulates;
- Specific constituent metals or radionuclides in airborne dusts; and
- Radon gas.

The potential sources of these contaminants from the activities proposed during implementation of the Proposal would be:

- Particulates from wind erosion and mechanical handling of overburden during land clearing and mining. Dust would also be generated by traffic along the mine access and haul roads. The materials contributing to airborne dust would be a mix of dunal sands, calcrete lumps and fines, clays and materials used in constructing the roadbase. Particulates from these sources are non-mineralised and would have low associated radionuclide concentrations;
- Particulates arising during excavation, loading and hauling ore. Although the mineralised ore would have higher radionuclide concentrations than those found in overburden, the ore would be damp, and little dust would be expected;
- Particulates from ore stored and handled at the centipede run of mine stockpile and plant;
- Particulates from wind erosion at the Millipede/Centipede tailings beach;
- Particulates from salt which may accumulate in evaporation ponds;
- Radon from tailings backfilled into Millipede/Centipede pit voids;
- Radon gas from the ore bodies, stockpiles and at Millipede/Centipede drying and packaging plant exhaust; and
- Emissions from combustion sources including power generation, boilers and vehicles.

Mining and processing of ore has the potential to increase atmospheric concentrations of greenhouse gases by:

- Emissions of carbon dioxide and nitrogen oxides as the result of burning fossil fuels in mobile equipment and power generating facilities;
- Emissions of carbon dioxide and other greenhouse gases as a result of transport of people and goods; and
- Contributing to the loss of carbon uptake by plants as a result of vegetation clearing.

The Proposal also has the potential to reduce atmospheric concentrations of greenhouse gases by providing an efficient, non-fossil fuel source of energy to international energy producers.

Impact Assessment – Millipede

Toro has assessed the potential impacts associated with atmospheric emissions from its proposed operations by:

- Reviewing previous air quality monitoring and modelling results;
- Measuring emissions from machinery and stockpiled materials during a field trial in August 2010;
- Reviewing published information for comparable mining activities elsewhere in Australia; and
- Conducting air quality modelling in accordance with methods specified in relevant government guidelines.

The results of the air quality assessment at Millipede are summarised below.

Modelling of air quality impacts focussed on when the maximum emissions are predicted to occur. This would be Year 4 at Millipede.

To inform the assessment, Toro identified the key radiological dust sources in the mining and processing of uranium ores, as follows:

- Mining of ore;
- Ore stockpiles
- Ore transfer processes crushing, road haulage and conveyor systems;
- Wind erosion of tailings deposits;
- Transport systems in the mill area (conveyors, etc.); and
- Uranium oxide drier and packaging area at Millipede.

The estimated radionuclide content of the different dust emission sources is shown in Table 18.2.

Table 18.2: Key sources of airborne radionuclides at Millipede

Source	Specific Activity per radionuclide (Bq/g)	Relative Radionuclide Content (Bq/α dps)				
		U^{238}/U^{234}	Th^{230}	Ra^{226}	Pb^{210}	Po^{210}
Mining	7.4	0.2	0.2	0.2	0.2	0.2
Tailings	7.4	0.0	0.33	0.33	0.2	0.33
Processing	7.4	0.2	0.2	0.2	0.2	0.2
Uranium Oxide	~10,000	0.5	0.0	0.0	0.0	0.0

Note: specific activity assumes 600 ppm in ore and units of relative radioactivity are Bq per alpha disintegration per second.

Emissions of particulates were estimated on an hourly basis based on the operations at the time and the winds. This results in variable emissions that are input to the dispersion model for that hour. Summaries of the estimated average and maximum PM_{10} emissions from the operations at Year 4 are presented in Table 18.3. As shown in the table, the total average PM_{10} emissions would be about 530 tpa. Maximum dust emissions occur under dry conditions, with very strong winds. This is shown by the considerably higher emission rates associated with wind erosion from TSF, stockpiles and bare ground in the mine. Processing of ore does not generate significant quantities of dust.

Table 18.3: PM_{10} emission estimates at Millipede

	Activity	Year 4 Average (g/s)	Year 4 Maximum (g/s)
Mining operations	Surface Miner	0.63	1.0
	FELs loading trucks	2.7	20
	Haul truck dumping to ROM at mine	-	-
	Haul truck dumping waste to old pits	0.78	5.9
	FEL loading at mine ROM	-	-
	Road train dumping at plant and plant ops	0.21	1.6
	FELs at plant ROM	0.14	1.3
	Graders at mine	0.26	0.35
	Dozers at mine (total of two)	1.67	2.22
	Grader on LW to plant road (day only)	-	-
	Total	**6.4**	**32.6**
Vehicle movements	Light vehicles LW to plant	-	-
	Light vehicles plant to Millipede	0.35	0.9
	Haulage to ROM (at mine)	1.4	2.2
	Haulage of waste to old pits	1.1	1.7
	Road train LW to plant	-	-
	Total	**2.8**	**4.8**
Wind erosion	Mine area	2.39	237
	Rehabilitation areas (new)	0.39	55
	Surrounding areas and soil stockpiles and roads	0.76	106
	Waste stockpile	1.5	212
	ROM pad area	0.14	19.3
	Beach areas in tailing area	2.4	341
	Total	**7.6**	**1,069**
	Total	**16.8** **(530 tpa)**	**1,106** **-**

Notes: 1. Based on the 2009/2010 meteorological year
2. Values may not tally due to rounding and may not tally as maximums may not occur at the same hour.
3. Values will be conservative in that no suppression due to rainfall is assumed.

The predicted maximum and average distributions of total suspended particulates, PM_{10} particulates, $PM_{2.5}$ particulates and deposited dust during Year 4 of Project implementation (being the year of maximum emissions during Years 1 to 5 of operation) are shown in tabular summaries of predicted average and maximum particulate concentrations at the nearest sensitive receptors provided in Table 18.4. Predicted dust deposition rates are summarised in Table 18.5.

Table 18.4: Predicted particulate concentrations above background and percent of criteria – Millipede

Location	Max. 24-hr average TSP (µg/m³) and (percent of criteria)	Max. 24-hr average PM_{10} (µg/m³) and (percent of criteria)	Maximum 24-hr average $PM_{2.5}$ (µg/m³) and (percent of criteria)	Annual average TSP (µg/m³) (and percent of criteria)	Annual average $PM_{2.5}$ (µg/m³) and (percent of criteria)
Toro House	1.8 (2%)	1.1 (2%)	0.2 (1%)	0.2 (0%)	0.03 (0.4%)
Apex Village	2.4 (3%)	1.8 (4%)	0.3 (1%)	0.2 (0%)	0.03 (0.4%)
Wiluna Town	1.5 (2%)	0.9 (2%)	0.2 (1%)	0.1 (0%)	0.02 (0.3%)
Toro accommodation village	56 (62%)	29 (59%)	5.7 (23%)	1.1 (1%)	0.14 (1.8%)
Lake Way Station	4.9 (5%)	3.3 (7%)	0.6 (3%)	0.1 (0%)	0.02 (0.3%)
Millbillillie Station	2.4 (3%)	1.7 (3%)	0.3 (1%)	0.1 (0%)	0.02 (0.2%)
Ngangganawili Community	3.6 ((4%)	2.1 (4%)	0.4 (2%)	0.2 (0%)	0.002 (0.3%)
Bondini Reserve	1.4 (2%)	1.0 (2%)	0.2 (1%)	0.1 (0%)	0.02 (0.2%)
Criteria	**90**	**50**	**25**	**90**	**8**

Table 18.5: Predicted dust deposition (above background) at sensitive receptors – Millipede

Location	**Predicted Max. Monthly Deposition Rates (g/m²/month)**	**Predicted Annual Deposition Rates (g/m²/month)**	**Annual Deposition Rate as Percentage of NSW Criteria**
Toro House	0.009	0.003	0.1%
Apex village	0.010	0.003	0.2%
Wiluna Town	0.007	0.002	0.1%
Toro accommodation village	0.007	0.002	0.1%
Lake Way Station	0.010	0.003	0.1%
Millbillillie Station	0.012	0.003	0.1%
Ngangganawili Community	0.023	0.004	0.2%
Bondini Reserve	0.009	0.002	0.1%

Note: The NSW criterion is an incremental increase of annual average of 2 g/m²/month, expressed on a monthly basis. Maximum monthly values were calculated for use in the radiation assessment in Toro (2011a) and are presented here for completeness.

The tables show for the first five years of mining (when operations mainly occur within and near the Millipede/Centipede deposits):

- Particulate concentrations are greatest to the north-west of the operational areas due to the prevailing south-easterly winds.

- The only sensitive human receptor site potentially exposed to significant dust concentrations is Toro's accommodation village, where the predicted maximum dust concentrations resulting from Toro's operations (and including background dust levels) are 98% and 91% of the relevant air quality criteria. It is noted that the TSP criterion is based on the Kwinana residential standard which is 'desirable not to be exceeded'. The predicted maximum total airborne dust concentration (including background levels) is approximately 59% of the Kwinana residential limit of 150 μg/m^3. The relatively high dust concentrations predicted at the Toro accommodation village are partly the result of a single model event in which one day had very persistent high winds blowing from the mine towards the accommodation area (Air Assessments, 2011). A typical year's maximum concentration of dust would be much lower than the worst case value predicted by modelling.
- The predicted concentrations of airborne PM_{10} during the first five years of mining generally meet the NEPM criterion, which for the purposes of this assessment has been interpreted as allowing for no exceedances of 50 μg/m^3 (24-hour average). Except for the Toro accommodation village, the predicted maximum PM_{10} levels at sensitive receptors are well below this.
- Other than at the Toro accommodation village, airborne particulate concentrations are no more than 7% of relevant particulate criteria at any other receptor.
- Predicted dust deposition rates are relatively low.

Impact Assessment – Lake Maitland

Particulate matter emission sources during the construction period would consist of all activities that have the potential to generate dust, including the following:

- Vehicle traverse of access roads;
- Mobile plant diesel consumption;
- Ore extraction from the active pit;
- Flood protection bund construction;
- Borrow pit stockpiles and excavation;
- Water management facility construction; and
- Power plant diesel consumption.

Particulate metal sources of emissions include all dust generating activities located on the deposit. This includes ore extraction from the active pit, flood protection bund construction and water management facility construction.

Similarly, radon sources during construction would include all activities associated with ore extraction and handling. Identified radon sources include:

- Water management facility – abstracted water; and
- Ore extraction from the active pit.

When mining at Lake Maitland was at its most active, emission sources would include:

- Continuing pit preparation for future mining;
- Borrow pit activities and topsoil stockpile;
- Rehabilitated pits;
- Ore extraction;
- Overburden stockpiles; and
- Vehicle traverse on access roads.

Emission rates for each of the identified mining sources have been calculated using Emission Estimation Technique Manuals published by the National Pollutant Inventory (NPI) and AP-42 emission factors published by the United States Environmental Protection Agency (USEPA).

Emission estimation has been conducted to assess worst case operating conditions. Consequently, it has been assumed that all identified surfaces would be exposed simultaneously and that all activities would occur constantly throughout the designated time. Other parameters used for estimating emissions to air at Lake Maitland included air, meteorological and dispersion modelling.

Overall, the TSP modelling showed that all contaminants would comply with the established modelling criteria of 90 µg/m^3 (Table 18.6).

Table 18.6: Air dispersion modelling results, Lake Maitland: TSP

	Construction Year	Year of Maximum Site Activity
Averaging Period	24 hours	24 hours
Accommodation Village (Project impacts only)	34 µg/m^3	52 µg/m^3
Accommodation Village (Cumulative impacts - including background concentration)	73 µg/m^3	84 µg/m^3
Barwidgee Station (Project impacts only)	6.45µg/m^3	9.6 µg/m^3
Barwidgee Station (Cumulative impacts including background concentration)	45 µg/m^3	49 µg/m^3

The modelling predicted that the concentrations of airborne PM_{10} would meet the NEPM criterion allowing for no exceedances of 50 µg/m^3 (24 hour average) (Table 18.7).

Table 18.7: Air dispersion modelling results, Lake Maitland: PM_{10}

	Construction Year	Year of Maximum Mining Activity
Averaging Period	24 hours	24 hours
Accommodation Village (Proposal impacts only)	32 µg/m^3	31 µg/m^3
Accommodation Village (Cumulative Impacts – including background concentration)	46 µg/m^3	45 µg/m^3
Barwidgee Station (Proposal impacts only)	4.7 µg/m^3	4.9 µg/m^3
Barwidgee Station (Cumulative Impacts – including background concentration)	19 µg/m^3	19 µg/m^3

The maximum predicted $PM_{2.5}$ concentrations at the two sensitive receptors are presented in Table 18.8.

Table 18.8: Air dispersion modelling results, Lake Maitland: $PM_{2.5}$

	Construction Year	Year of Maximum Mining Activity
Averaging Period	24 hours	24 hours
Accommodation Village (Proposal impacts only)	3.1 µg/m^3	5.3 µg/m^3
Accommodation Village (Cumulative Impacts – including background concentration)	20 µg/m^3	22 µg/m^3
Barwidgee Station (Proposal impacts only)	0.44 µg/m^3	0.85 µg/m^3
Barwidgee Station (Cumulative Impacts – including background concentration)	18 µg/m^3	18 µg/m^3

The modelling predicted that the concentrations of airborne $PM_{2.5}$ would meet the NEPM criterion allowing for no exceedances of 25 µg/m^3 (24 hour average).

The maximum predicted dust deposition rates for insoluble solids are presented in Table 18.9 for sensitive receptors.

Table 18.9: Maximum predicted dust deposition rates for insoluble solids – Lake Maitland

	Construction Year	Year of Maximum Mining Activity
Averaging Period	1 month	1 month
Accommodation Village (Proposal impacts only)	0.28 g/m^2/month	0.14 g/m^2/month
Accommodation Village (Cumulative Impacts – including background concentration)	2.3 g/m^2/month	2.1 g/m^2/month
Barwidgee Station (Proposal impacts only)	0.041 g/m^2/month	0.031 g/m^2/month
Barwidgee Station (Cumulative Impacts – including background concentration)	2.1 g/m^2/month	2.0 g/m^2/month

The criterion for dust deposition is 4 g/m^2/month.

The air dispersion modelling results for radon are presented in Table 18.10 for each sensitive receptor location.

Table 18.10: Air dispersion modelling for radon – Lake Maitland

	Construction Year	Year of Maximum Site Activity
Averaging Period	24 hours	24 hours
Accommodation Village (Project impacts only)	21 Bq/m^3	283 Bq/m^3
Accommodation Village (Cumulative impacts - including background concentration)	170 Bq/m^3	433 Bq/m^3
Barwidgee Station (Project impacts only)	2.9 Bq/m^3	29 Bq/m^3
Barwidgee Station (Cumulative impacts including background concentration)	150 Bq/m^3	180 Bq/m^3

The maximum criterion for radon is 1000 Bq/m^3 expressed as an annual average. Predicted maximum ambient radon concentrations during Project implementation are well below the ambient radon criterion.

In summary, the modelling assessment showed that all modelled contaminants comply with the established criteria.

Energy and Greenhouse Gases

Toro has undertaken an analysis of Project greenhouse emissions under two scenarios:

- The main fuel source for the Project is diesel; or
- Power generation using natural gas.

The analysis took into account both direct and indirect emissions. That is, the analysis looked at greenhouse gases emitted from facilities at the Project itself, and also considered the greenhouse gases generated by activities (such as road transport of reagents required in the processing plant and travel by employees and contractors) required to implement the Project.

The analysis found that use of natural gas rather than diesel as the primary fuel source would result in a reduction of approximately 20% in greenhouse gas emissions. Toro's preferred option is to use natural gas, rather than diesel, for most of its power generation requirements. Diesel would only be used at satellite pump stations to power lights etc. and would be stored as an emergency back-up if the gas supply was interrupted for short periods.

Impact Management

Project air quality monitoring and follow-up programs would be designed and implemented under the following categories:

- Compliance inspection: Monitoring the activities, procedures, and programs undertaken to confirm the implementation of approved design standards, mitigation, and conditions of approval and company commitments;
- Environmental monitoring: Monitoring to track conditions or issues during the development lifespan, and subsequent implementation of adaptive management; and
- Follow-up: Programs designed to test the accuracy of impact predictions, reduce uncertainty, determine the effectiveness of environmental design features, and provide appropriate feedback to operational management for modifying or adopting new mitigation designs, policies, and practices. Results from these programs would be used to increase the certainty of impact predictions in future environmental assessments.

A comprehensive Dust Management Plan would be implemented for the Project. The Plan would:

- Designate responsibilities for the management of dust and implementation of ongoing control mechanisms;
- Include practical control procedures such as routine watering of access and haul roads and the possible scheduling of dust generating activities under favourable wind conditions;
- Identify responsibilities for contractors, visitors, managers and include an environmental induction program; and
- Include ambient air quality monitoring for TSP, insoluble solids dust deposition, PM_{10} and $PM_{2.5}$ at the accommodation villages. Monitoring results would be assessed against Project ambient air quality criteria and used to inform site operations and minimise off-site impacts.

In particular, the Dust Management Plan would prescribe the controls to be implemented to meet the assumed dust suppression modelled in the air quality impact assessment.

Predicted Outcomes

Air quality impact assessment modelling indicates that all contaminants of interest would meet relevant compliance criteria. Implementation of the Proposal would not detract from the maintenance of air quality for the protection of the environment and human health and amenity. Use of natural gas as the primary fuel source would result in a significant reduction in greenhouse gas emissions compared with using diesel while implementation of the Proposal would support Australia's efforts in global greenhouse reductions by providing an alternative to more greenhouse gas intensive fuels. The assessment used a number of worst case elements, which added an element of conservatism and confidence to the predictions.

19 SOCIAL FACTORS

This section discusses aspects of the human, social and cultural environment which affect or may be affected by the Extension to the Wiluna Uranium Project. Based on social impact assessment work, it also considers measures to maximise potential benefits and minimise adverse social impacts.

19.1 Setting

The Millipede and Lake Maitland deposits are located within the sparsely populated Murchison region of Western Australia on the western edge of the Western Desert which also extends into the Northern Territory and South Australia. Both deposits are in the Shire of Wiluna. The land surrounding the deposits has a history of Indigenous, pastoral and mining uses. Millipede is on the Lake Way pastoral lease and Lake Maitland is on the Barwidgee pastoral lease. Both leases are held by Toro and are sub-let for grazing livestock. Stock would be excluded from the operational areas during the construction and mining phases.

The nearest population centres are shown in Table 19.1.

Table 19.1: Local population centres relevant to the Proposal

Township	Local Shire	Approximate Distance		Population (2011 Census)
		To Lake Maitland	To Millipede	
Kalgoorlie	Kalgoorlie-Boulder	400 km	475 km	30,842
Leinster	Leonora	95 km	170 km	1294
Leonora	Leonora	185 km	260 km	1216
Laverton	Laverton	207 km	282 km	1023
Meekatharra	Meekatharra	260 km	185 km	812
Menzies	Menzies	276 km	371 km	180
Wiluna	Wiluna	105 km	30 km	1159

19.2 Wiluna

The town of Wiluna is the major commercial centre in the Shire of Wiluna. The town is approximately 960 km north east of Perth and has a ‘very remote’ Australian Census classification. The shire covers an area of 182,154 sq km.

Wiluna is linked by modern transport infrastructure to communities to the south and Western Australia’s capital city, Perth.

A commercial air service provides flights between Perth and Wiluna on Mondays, Wednesdays and Fridays. The Goldfields Highway is a state highway extending almost 800 km from south of Kambalda to Meekatharra. The section from Kambalda is sealed all the way to Wiluna, taking in Kalgoorlie, Menzies, Leonora and Leinster. The section between Wiluna and Meekatharra is about 180 km in length, with most of it unsealed. This section provides an important east-west transport link between the Northern Goldfields and the Mid West, Gascoyne and Pilbara regions. It also forms part of the preferred route to link these regions through the Government of Western Australia’s Portlink project. In 2012, the state government initiated a $20 million upgrade of the road.

The principal industries in the Shire of Wiluna are mining and pastoralism. The shire hosts operating gold and nickel mines. Tourism has also become increasingly important with about 1000 people annually travelling the Canning Stock Route between Wiluna and Halls Creek in the Kimberley region. This is the world's longest historic stock route covering a distance of 1850 km.

Just over 70% of the Shire of Wiluna population of 1159 is male. Aboriginal and Torres Strait Islander people make up just over 25% of the population. The median age is 34. Children aged under 14 comprise just over 10% of the population and those over 65, 3.1%

At the last census in 2011, there were 757 people in the shire who reported being in the labour force. Of these, just over 77% were employed full-time, 8.9% part-time and 4.5% were unemployed. The main occupations were machinery operators and drivers (27.3%); technicians and trades workers (27.1%); professionals (15.1%); labourers (12.7%); and community and personal service workers (6%). More than half of those employed worked in basic non-ferrous metal manufacturing, mining and other mining support services.

Wiluna has a highly transient population due to its remoteness and the number of fly-in/fly-out employees in the local and regional mines. At the 2011 Census, just over 900 people were recorded as non-residents of the town (ABS, 2011).

The Shire of Wiluna Council has seven elected members. The shire provides a range of services including sport and recreation; library; environmental, health and building; emergency services; and fire control.

In May 2010, the Council resolved that 'the Chief Executive Officer bring a report back to Council that will prompt discussion of points of relevance on Council's official position in regard to uranium mining.' In preparing the report, the Chief Executive Officer sought information from organisations in support of and opposed to uranium mining. Toro provided input to information presented to the shire on behalf of the uranium industry. As a result of the report of the Chief Executive Officer, in September 2010 the Council adopted the following position:

> 'The Shire of Wiluna supports continuing exploration for uranium in the Shire and will consider giving its approval to applications to mine uranium on the understanding that any company proposing to mine uranium will:
>
> - Comply fully with all statutory requirements;
> - Give a clear undertaking that it will strive to attain best practice and zero harm in its operations at all times;
> - Work with the Council to assess the likely social, economic and environmental impacts on the Shire;
> - Include Council in all community investment and development planning and social impact assessments it may undertake; and
> - Work with the Council to develop and implement a Community Development Plan over the projected life of the mine so as to create a sustainable environment for the community now and in the future.' (Minutes of the Council of the Shire of Wiluna – 8 September 2010)

In 2012, the shire adopted a Strategic Community Plan to help shape the services it will deliver over the following 11 years. The shire's vision is for 'a proud, green, go-ahead and healthy Wiluna.' The five themes of the Plan are:

- **Proud Wiluna**: Celebrate Wiluna's rich cultural diversity and heritage, and support the community to share its unique stories and culture, and drive positive change;
- **Green Wiluna**: Responsible management of the natural and built environment and improve the attractiveness of Wiluna streets and public spaces;
- **Go Ahead Wiluna**: Build a stronger local economy in Wiluna through effective and responsible planning, and creating more opportunities for small business and employment;
- **Healthy Wiluna**: Support healthy lifestyles and ensure that the community is safe and feels safe; and
- **Leading Wiluna**: To ensure strong governance and that community expectations are addressed.

A hub for the Wiluna community is the Ngangganawili Aboriginal Health Service (NAHS). NAHS was established in 1993 as a community-controlled Aboriginal corporation and health and medical service to provide affordable and culturally appropriate services to the Aboriginal and wider population of Wiluna and surrounding areas. It is unique in Western Australia in that, as an Aboriginal-controlled organisation, it is also the sole provider of health care services across the Shire of Wiluna, including contracted services to the mining industry.

NAHS provides a round-the-clock first response ambulance team for accidents and emergencies. Annually, the service delivers more than 10,000 episodes of health care to up to 4000 Indigenous and non-Indigenous clients and has now developed into a place where people come to meet and connect with health and lifestyle programs, and information about town activities. Toro makes an annual financial contribution to NAHS.

The Wiluna Remote Community School provides education from kindergarten until Year 12 and a local TAFE delivers vocational training including courses in automotive, horticulture, building and construction, textiles and art. Local residents are active participants in community sport and arts projects.

The resident Aboriginal population is dominated by the Martu and Ngaanyatjarra people, with strong links to the Goldfields (Wongi) and Mid West (Yamatji) people. Regular contact occurs between Aboriginal people from Wiluna, the Punmu and Jigalong communities to the north and the Ngaanyatjarra communities to the east.

About half of the Indigenous population in the shire live in Wiluna or at Bondini, about 5 km east of the town. Other communities in the shire include:

- Kutkububba (30 km north of the town);
- Windidda pastoral lease (200 km east); and
- Ululla pastoral station (70 km south-west).

As well as extensive consultation with Aboriginal people, Toro has developed links with the Wiluna community through its support and membership of the WRPA and the Murlpirrmarra Connection which encourages Aboriginal education, interaction, self-esteem and employment prospects.

19.2.1 Martu Attitudinal Survey

In 2013, a Martu attitudinal survey was undertaken in Wiluna and surrounding communities under the auspices of the WRPA. The survey was researched, conducted and analysed by the Muntjiljtarra Wurrgumu Group (MWG) comprising the Wiluna, Bondini, Kutkububba, Ngurra Yuldoo and Windidda communities. The MWG was established as part of the WRPA.

The main themes to emerge from the survey results focused on the importance the Martu attach to family and culture and the need for greater leadership and support mechanisms. Barriers and opportunities relating to employment, training and enterprise development were linked to these major themes.

Table 19.2 summarises the key survey findings (MWG, 2013).

Table 19.2: Martu attitudinal survey

Theme	Findings
Opportunities	• Most Martu People say they want to work, especially young people. • As people get older, they are more willing to travel away for training. Martu have a lot of ideas about the kind of training they need. The main ones are in shire-type work, contracting, being able to work on cars and in enterprise development. • More cross-cultural training and awareness in workplaces would result in better relationships and greater understanding of Martu. Practical things could be addressed to improve the chances of successful Martu participation in mining (and other employer) work, especially regarding transport to and from mine sites; and • There is a high interest by the Martu in developing businesses. They have good memories of working in their own businesses in the past when people felt they had more control and pride.
Barriers	• No driver's licence; the number of Martu without a licence is greater than the number with one. This is especially the case for those aged under 30. • Family responsibilities and 'too much humbug' from families. • Lack of childcare facilities is a major issue for women. • Concern about alcohol and volatile substance use issues, especially their impact on young people. • Racism in workplaces is a deterrent to many Martu seeking work. • Insufficient cultural sensitivity and respect for Aboriginal people in many workplaces. • Martu feel there is a lot of discrimination by employers and a reluctance to 'give them a go'. There is also discrimination relating to lack of transport, access and health problems. • There are limited opportunities for Martu to get a job in Wiluna. • Martu are often not aware of job vacancies as mining companies in particular advertise through websites. Most Martu do not own a computer or utilise the internet for seeking work. Most people use a mobile phone. • A lot of young people do not know their options and are misinformed about what they need to get a job; and • There is a need for more training and support for Martu to get more Martu working.
Attitudes to employers and work	• 'What makes a good boss' for Martu are bosses who respect Martu and give them a go and who understand Martu people and their culture. • Martu see the top bosses as those who help Martu to work on country and with their own people. • Mining employers are favourably rated, with the highest rating mining company jobs being: 'working on country' (rangers, land rehabilitation – rated highest by men); camp provider service sector (catering, cleaning, cooking – rated highest by women). • Working underground in the mines is considered the worst mining job for Martu; and • The main ways that mining companies can get more Martu to work are by helping with transport, having more ranger programs, providing on-the-job training and understanding that Martu have a lot of family responsibilities and cultural obligations.

Theme	Findings
Martu prefer jobs that	• Don't keep them away from their families; • Allow flexible work hours and conditions; • Allow people to drive in and out of the workplace; • Understand obligations to family and culture; • Are on country; • Let them work with their own 'mob'; • Have good supervisors who know how to talk to the Martu properly; and • Have the right kind of support.

For its conduct of this survey, MWG won a highly commended award in the 2014 Reconciliation Australia Indigenous Governance Awards. The award was presented to MWG by the Prime Minister.

19.2.2 Wiluna Socio-economic Impact Assessment

The Martu Attitudinal Survey builds on a contemporary understanding of the Wiluna community also supported by a Socio-economic Impact Assessment (SIA) commissioned by Toro through Creating Communities Pty Ltd (Creating Communities).

At an early stage in this work, it was recognised that the Wiluna community was experiencing 'consultation fatigue' because of the number of new mining proposals being developed or advanced for the region and the need for project proponents each to undertake community and stakeholder consultation. To relieve this pressure on the Wiluna community, where possible this SIA drew on already available information and data to augment the consultation undertaken by Creating Communities and Toro. Much of the consultation was undertaken through the Community Reference Group of the WRPA.

A SIA is a means to anticipate and plan for social impacts prior to the development of a project. The objectives of a SIA are to:

- Understand impacts and change in advance of the event;
- Help communities and stakeholders understand how project development may impact on social outcomes;
- Maximise the benefits and minimise the costs of social change;
- Identify alternatives in achieving project goals and community aspirations; and
- Establish a basis for impact mitigation.

The SIA of the Wiluna community specifically sought to:

- Understand social impacts at Wiluna and regional locations on the supply and transport route, although with a strong focus on Wiluna because of its close proximity to proposed uranium mining;
- Identify and communicate to Toro, stakeholders and affected communities any significant social impacts; and
- Identify and recommend means to maximise opportunities and benefits for communities as a result of mining, and minimise potential adverse impacts.

This SIA was undertaken during assessment of proposed mining at Centipede and Lake Way, but before Toro acquired ownership of the Millipede and Lake Maitland tenements. In its consultation at the time, however, Toro made it clear that it was seeking to acquire additional tenements in the region providing the potential for mining over a longer period.

Summary of Key Issues Identified During the Wiluna SIA

- Support for more mining activity in the region, because of the potential to provide more employment and skills development;
- Support for more mining activity in the region, because of the potential to provide business for local and regional contractors and possibly underpin new town infrastructure;
- Concern in Wiluna that recent mining activities had not generated much benefit for the community because of their reliance on fly-in/fly-out arrangements for their workforces;
- The need for companies to encourage local recruitment of their workforces to the extent possible and where there is external recruitment, encourage young couples and 'empty nesters' who may be willing to live locally, with the partners of such employees able to help provide services in the community, such as teaching, nursing and job training;
- The need for some flexibility in recruitment and human resource practices to accommodate Aboriginal culture in encouraging Indigenous employment;
- Providing job training with a view to establishing skills that may be transferable after mining ends;
- Concern that because of an increase in mining activity, there may be a labour shortage affecting the capacity of local businesses and forcing up contractor rates;
- Concern about Aboriginal influences in the town being overwhelmed by non-Indigenous cultures;
- Pressure on local and regional services from a bigger population; and
- Concern about the impacts of uranium mining on public health and safety, including through product transport.

Impacts of a Changing Community Profile

The SIA assessed overall population trends with a particular focus on the potential for a rise in the non-Indigenous and non-residential populations of Wiluna. As a result, the following potential negative impacts were identified from a changing community profile:

- The mining industry absorbing all community capacity, including in infrastructure and service availability and delivery;
- Benefits from mining activity largely occurring elsewhere because of fly-in/fly-out workforce arrangements;
- Tensions between permanent residents and an increasing number of non-permanent residents;
- Anti-social behaviour by non-permanent residents;
- Fragmentation of the community, a loss of authority of Aboriginal Traditional Owners and incompatibility between Indigenous and non-Indigenous cultural practices;
- Fewer people having an ongoing commitment to local community development;
- Differences within the community about uranium mining; and
- Pressures on housing availability and affordability.

The SIA also identified that to the extent the Toro workforce is non-Indigenous, there are likely to be differences in cultural practices in relation to:

- Spiritual beliefs and practices, particularly concerning land care and use;
- Family and community cultural obligations, particularly at certain times and occasions, such as funerals, Law time;
- Attachment to family and home 'country' which can impact on availability or preference for shift and type of work and mine camp living; and
- Incompatibility between a mining culture and Aboriginal family and home life.

The SIA identified the following potential benefits of a growing population based on increased mining activity:

- Employment and business opportunities with an increased market for local goods and services;
- Increased opportunities for training and skills development;
- Integration of community and industry infrastructure needs;
- Greater viability for recreational and leisure facilities; and
- Opportunity to recruit workers who will add to the diversity of the community, particularly those possessing skills that can be used in building community capacity, e.g. volunteers for sporting and community groups, professional partners of mine employees.

In its Environmental Review and Management Program (ERMP) for mining at Centipede/Lake Way, Toro made a series of commitments in response to the SIA to seek to minimise the adverse impacts and maximise the benefits of a changing community profile. Toro makes the same commitments for the Extension to the Wiluna Project should it be approved and is able to proceed. They are:

- Close consultation and collaboration with other mining companies, government and the Shire of Wiluna in infrastructure and service delivery planning and development;
- Consideration of establishing some housing in Wiluna for operational management;
- Support for the Shire of Wiluna Strategic Plan and as an adjunct to the Plan, in consultation with the shire, establish a Community and Economic Development Plan to guide and manage community and workforce integration;
- Provide opportunities for local businesses to tender for supply and service contracts;
- To the extent practicable, encourage fly-in/fly-out employees and contractors to make use of local recreational services and negotiate with the shire a shared services agreement to further develop the capacity of such services;
- Negotiate a shared services agreement with the NAHS, including for the provision of workforce health monitoring;
- An emphasis in operational workforce recruitment on local and regional residents, young couples and older couples with children no longer living at home who would be prepared to live in Wiluna;
- Recruitment and human resources practices to have flexibility to accommodate Aboriginal culture;
- Cross-cultural awareness training for mine employees and contractors;
- Financial support for sustainable community development through negotiation of mining agreements with Native Title Holders and Claimants; and
- Toro to have a community office in Wiluna to ensure that Project information is readily available and to permit ongoing engagement between the company and the community.

Consultation for the SIA and by Toro in Wiluna and the region has identified concerns about impacts on public health from radiation as a result of uranium mining and finished product transport. Specifically, concerns have been raised about the long-term effects of radiation on the environment and the health of communities as a result of:

- Contamination of water and bush tucker; and
- Transportation of product, should an accident occur.

There are also community concerns about the risk of vehicular accidents during the construction phase when traffic volumes would be higher than during the operational phase, and about the availability of alcohol should the workforce use facilities in the Wiluna Township. The outcomes of bush tucker surveys are discussed in Section 14. Transport safety issues are addressed in Section 19.7.2. The issue of anti-social behaviour is discussed in Section 19.8.

19.3 Socio-economic Impact Assessment – Lake Maitland

A SIA was conducted by Mega to support its environmental assessment. The results remain relevant to a consideration of the impacts of the Extension to the Wiluna Project in that they deal with mining at Lake Maitland and associated mineral processing proposed by Toro which would occur at the same scale and for the same duration as that contemplated at the time this SIA was undertaken.

The Lake Maitland SIA identified and focused on three geographical areas:

- Local Study Area (LSA): Defined as the Wiluna and Leonora Local Government Areas (LGAs) by the ABS. Lake Maitland is in the south-east corner of Shire of Wiluna, adjacent to the Shire of Leonora boundary. The mine site is about 185 km north of the Leonora township and 105 km south-east of Wiluna.
- Regional Study Area (RSA): Comprising areas that are adjacent to the Lake Maitland site and the proposed roads to be used to link to the main transport hub at Kalgoorlie. This includes the Meekatharra, Laverton, Menzies, Coolgardie, Dundas and Kalgoorlie-Boulder LGAs. The communities within this secondary study area may experience secondary social and economic impacts, such as employment and business opportunities, and also some traffic impacts.
- The State of Western Australia (beyond regional): Defined as the broader state of WA, and considered to the extent that mining at Lake Maitland has economic impacts at the state level.

19.3.1 Pathways of Potential Impacts

Table 19.3 presents examples of the range of key questions and indicators used in the SIA. The questions and key indicators shown represent the pathways of potential impacts on relevant socio-economic values.

Table 19.3: Summary of socio-economic pathways of potential impact

SIA Aspect	Key Question	Key Indicator
Demographics	What potential impact will the workforce have on the demographics of communities in the study areas?	• Population size • Age profile • Sex profile • Household size and structure • Ethnic composition (% of Indigenous population in overall population)
Education and Training	What will be the impact on education and skill levels of communities in the study areas?	• Education levels • Employment skills and training • Literacy levels
Livelihood and Lifestyle	What will be the impact on people's way of life in the study areas?	• Use of and access to traditional land • Community cohesion (including fly in/fly out families) • Amenity and liveability of local environment
Housing and Accommodation	What will be the impact on housing and accommodation in the study areas?	• Rental price • Real estate value

SIA Aspect	Key Question	Key Indicator
Social Infrastructure and Services	What will be the impact on social infrastructure and services in the study areas?	• Quality and quantity of educational facilities and services • Capacity and provision of medial infrastructure • Capacity of waste management systems • Quality and quantity of welfare facilities and services • Quality and quantity of sport and recreation facilities and services • Quality and quantity of transport facilities such as roads, ports and airports
Cultural Heritage and Traditional Knowledge	What will be the impact on the cultural heritage and traditional knowledge of communities in the study areas?	• Indigenous and non-Indigenous cultural sites • Traditional system of production (bush tucker)
Macro-economy	What will be the impact on the economy?	• Revenue generation • Demand levels • Inflation
Employment	What will be the impact on the level and structure of the employment profile in the study areas?	• Employment opportunities and distribution • Business development opportunities and distribution
Income	What will be the impact on the level and structure of household income in the study areas?	• Household income levels • Distribution of income

Impact Assessment Criteria

The SIA was undertaken in a qualitative and semi-quantitative manner adapted from a range of good practice guidelines for social and economic impact assessment including:

- EPA, 2004. *Guide to EIA Environmental Principles, Factors and Objectives*, Western Australian;
- Department of Infrastructure and Planning, 2010. *Social Impact Assessment – Guideline to Preparing a Social Impact Management Plan*, Queensland;
- Burdge RJ, 2004. *The Concepts, Process and Methods of Social Impact Assessment*. Social Ecology Press; and
- International Association for Impact Assessment: International Guidelines and Principles for Social Impact Assessment, 2003.

Assessment Methods

The approach taken to the SIA had four stages (Table 19.4), with stakeholder engagement undertaken at each stage.

Table 19.4: Lake Maitland SIA process

Stage	Activity
1. Scoping	Identify affected population, issues, concerns and likely impacts
2. Profiling	Develop a profile of affected communities and collect information to identify potential impacts
3. Assessment	Assess each social and economic impact identified in the first two stages
4. Mitigation and Management	Develop mitigation measures and management plans to address identified potential impacts

The significance of each impact was assessed qualitatively and described in terms of the following five attributes:

- Direction: The impact on the LSA and RSA socio-economic environment could be positive, neutral or negative.
- Magnitude: The degree of change in a key indicator, classified as:

- Negligible: Impact unlikely to be detectable;
- Low: Effect may be detectable, but is small and highly unlikely to have any significance;
- Moderate: Effect will be detectable, but not severe; unlikely to lead to major changes to social and economic status of communities; or
- High: Effect likely to have severe negative or intense positive impact on social and economic status of communities.

- Geographic extent: The potential geographical area affected by the impact, classified as:

- Local;
- Regional; or
- Beyond regional.

- Probability: The likelihood of the occurrence of the impact, classified as:

- Certain: The impact is likely to occur during the life of the mine; or
- Probable: The impact may occur at least once during the life of the mine.

- Duration: The potential length of time over which an impact may occur, classified as:

- Short term: Typically associated with the construction phase;
- Medium term: Longer than short-term impacts, but do not extend beyond the operational life of the mine; or
- Long term: Impact extends beyond the operational and decommissioning stages (i.e. post-closure).

This qualitative assessment was conducted based upon consideration of the following information:

- Quantitative data gathered during baseline phase regarding impacts;
- Experiences of similar scale projects; and
- Informed judgments by the study team.

Following the impact assessment, the overall significance of the impact was determined. The overall impact is termed ‘social and economic consequence’. One of four levels of social and economic consequence was assigned:

- Negligible: The impact creates no noticeable change in the socio-economic environment in the study areas compared with the baseline conditions;

- Low: The impact has a small but noticeable impact on the socio-economic environment in the study areas compared with the baseline conditions;
- Medium: The impact has a marked but not excessive impact on the socio-economic environment in the study areas compared with baseline conditions; or
- High: Considerable impact on the socio-economic environment in the study areas compared with baseline conditions.

The nature and scale of mitigation measures for each impact, monitoring and reporting process was determined in terms of the level of assessed consequence of each impact. In addition, the effect of mitigation measures on the level of consequence was considered and the resulting residual impact assessed. Where the residual impact was assessed as having a moderate or high level of adverse consequence further mitigation measures were added and the residual impact re-assessed. This process was repeated until all impacts had a negligible or low level of adverse consequence.

19.3.2 Assessment Results

The SIA was conducted to provide a framework for understanding the potential social and economic impacts of uranium mining at Lake Maitland. The study considered the location, profile and available data for the LSA (the Shires of Wiluna and Leonora) and the wider RSA. Stakeholder feedback collected during consultation for the purposes of Lake Maitland's environmental assessment, engagement with Aboriginal people and other activities has also been considered as part of this work.

Importantly, the SIA required regular interaction with other ongoing technical studies. In addition to a desktop assessment of existing socio-economic data, the SIA was also informed by a comprehensive stakeholder engagement program undertaken by Mega for the purposes of preparation of the environmental assessment. This process provided an avenue for communicating with and collecting feedback from potentially affected communities in the SIA's study area.

Potential socio-economic impacts were assessed for a LSA consisting of the Shires of Wiluna and Leonora, and a RSA incorporating the Shires of Meekatharra, Laverton, Menzies and the City of Kalgoorlie-Boulder.

A broad desktop baseline study helped to inform the SIA by establishing a profile of social and economic conditions currently in existence for the communities living in each study area. Some key features of these communities include:

- Remote geographical locations with poor public infrastructure and limited access to some essential services;
- Highly variable fluctuations in population due, amongst other things, to mines opening and closing and Indigenous cultural obligations;
- Low levels of education and training;
- Proportionately high populations of Aboriginal people compared to other towns and regions; and
- Distinct gaps in levels of performance between Aboriginal and non-Aboriginal people including health, education, employment and income levels.

Impacts were assessed to be positive or negative in nature at levels described as negligible, low, moderate or high. The summary of results of the SIA showed the potential negative impacts of developing mining at Lake Maitland in the construction and operational phases are low to moderate. Mitigation measures were then identified to reduce the assessment to low or negligible.

Some key negative and moderate impacts identified in the SIA included:

- Impacts on education and training providers, due to demand for skilled workers (although this SIA was undertaken at a time when skills demand in the resources sector was at a higher level than more recently); and
- Impacts on workers and their families from the use of fly-in/fly-out shift arrangements.

Key negative and low impacts of particular interest to surrounding stakeholders included:

- Impacts on road safety from transport of uranium (Section 19.7.2); and
- Impacts on groundwater from the mining of uranium (Section 13).

Positive impacts were also assessed for their potential to be enhanced to maximise foreseeable benefits. The relatively small scale and short timeframe for mining at Lake Maitland would reduce the potential for impacts such as those that have been assessed for larger and longer-lasting projects elsewhere in Western Australia, particularly the Pilbara. Nonetheless, the SIA process has provided valuable data to assist an understanding of how some enhancement measures may increase the likelihood that mining at Lake Maitland could make a lasting positive contribution to local communities. This would include in particular:

- Employment opportunities for local and regional residents, both Aboriginal and non-Aboriginal people;
- Business opportunities for local and regional contractors and suppliers; and
- Improved skills and stronger work-readiness for both Aboriginal and non-Aboriginal people.

Overall, the qualitative desktop social and economic impact assessment found there were no potential impacts which could be regarded as having a high social and economic value or high negative impact. Some negative impacts were assessed as moderate, but were able to be reduced to low with the implementation of appropriate mitigation strategies.

19.4 Other Important Locations in the Region

19.4.1 Leinster

The nearest township to Lake Maitland is Leinster, about 95 km to the south-west. Leinster functions primarily to house and service staff and families connected to the BHP Billiton Nickel West underground mine at Leinster.

19.4.2 Leonora

Leonora is about 185 km to the south of Lake Maitland and shares a history with Wiluna built on the pastoral and mining industries. The town is busier than Wiluna, primarily because it is a major service town on the Goldfields Highway, the transport corridor for many of the mining operations in the Northern Goldfields. The town is also a base for a range of government services, more recently providing a former mining camp to the federal Department of Immigration and Border Services for accommodation of asylum seekers. Tourism is promoted with the Gwalia Historic Precinct on the outskirts of Leonora, where a mining museum provides an insight into the life of early miners through restored cottages on the edge of the original gold mine.

Leonora has a recreational and aquatic centre, sporting facilities and a library. Each year the town hosts Australia's richest mile foot race, The Golden Gift. The race is the centrepiece of a weekend of social and community-based activities which attract visitors from throughout Australia and overseas.

19.4.3 Laverton

Laverton is about 200 km south-east of Lake Maitland. In 1969, the discovery of nickel-bearing rocks at Mt Windarra, about 25 km north-west of Laverton, led to the famous Poseidon nickel boom. The Mt Windarra mine is currently being refurbished with the aim of resuming production and extending the mining activities to nearby tenements.

19.4.4 Menzies

On the Goldfields Highway about 130 km north of Kalgoorlie, gold mining continues in and around the town of Menzies today. The original discovery was in 1894 and some of the town's prominent buildings, including the Town Hall, Railway Station and Community School, are reminders of gold's heydays from late in the 19th century.

19.4.5 Kalgoorlie

The City of Kalgoorlie-Boulder is a regional centre and one of Western Australia's largest outside Perth with a population now exceeding 31,000. Finished product from Millipede and Lake Maitland would be transported on the city's eastern bypass road on its way to South Australia for shipment. Toro has consulted the City Council about its product transport plans.

19.5 Current Mining Projects in the Wiluna Region

In addition to the Wiluna Uranium Project, the following mines have been operating or proposed in the Wiluna region:

- Jundee Gold Mine: 45 km north-east of Wiluna. Opened in 1995 originally as an open pit operation with underground mining commencing in 1997. Ore is currently sourced only from underground. The mine was acquired by its current owner, Northern Star Resources Limited, in July 2014;
- Rosslyn Hill Mining: 30 km west of Wiluna. The open cut lead carbonate mine and concentrating facility exported to customers in China and other countries. It began production in 1995 and is operated by Rosslyn Hill Mining, wholly owned by Ivernia Inc, an international base metals mining, exploration and development company. In January 2015, the mine was put on care and maintenance because of low lead prices;
- Mount Keith Nickel Mine: 85 km south of Wiluna. An open cut mine which is part of BHP Billiton's Nickel West operations. These operations also include the Leinster Nickel Mine (200 km south of Wiluna), Kambalda Nickel Concentrator, Kalgoorlie Nickel Smelter and Kwinana Nickel Refinery;
- Bronzewing Gold Mine: 165 km south of Wiluna and 30 km south of Lake Maitland in the Shire of Leonora. This was an underground gold mine operated between 1991 and 2013. It was acquired by Metaliko Resources in early 2014 which plans an evaluation of exploration targets with a view to resuming mining. Bronzewing has an airstrip which could support any fly-in/fly-out requirements at Lake Maitland;
- Yeelirrie Uranium Project: 70 km south of Wiluna. One of Australia's largest undeveloped uranium deposits. It was discovered in 1972 and after extensive exploration by its previous owners, Western Mining Corporation and BHP Billiton, was acquired by Cameco in 2012;
- Wiluna West Iron Ore Project: 40 km west of Wiluna. The flagship project of Golden West Resources which plans to produce high grade, low impurity ore at a rate of up to 10 Mtpa; and
- Matilda Gold Project: Extends from 5 km east of Wiluna. This project was acquired by Blackham Resources in 2014. It is based on the former Apex mine which was an active underground gold producer from 1984 until its closure in mid-2013.

19.6 Management and Implementation

Toro would use the information in this section to help inform further community development and social investment initiatives, should this Proposal proceed, with the aim of providing sustainable benefits for local and regional communities lasting longer than the life of mining.

There would be a range of local employment and contracting opportunities in the construction, operational, closure and rehabilitation phases of the Extension to the Wiluna Project including:

- Site preparation;
- Earth moving;
- Earthworks;
- Welders;
- Electrical services;
- Cement supply;
- Fuel supply;
- Aircraft charter;
- Engineering;
- Drilling;
- Concrete work;
- Mine operators;
- Plant operators and technicians;
- Mine safety, including radiation safety;
- Road maintenance;
- Truck driving;
- Transport and logistics;
- Catering, laundry and cleaning services;
- Land and environmental management; and
- Community relations.

Toro would be committed to sourcing labour and contractors locally and regionally to the extent that they are available and it is economic to do so, and would continue support for job readiness and other initiatives to maximise such opportunities.

A priority of the WRPA has been to identify sustainable employment opportunities for Aboriginal people. Toro and the other mining companies with a presence in the Wiluna region are committed to continuing their active contribution to this work. Toro identified two Aboriginal people and an Aboriginal mentor as the first participants in its own training and employment program for the Wiluna Uranium Project, providing them with field work in a number of functions. Toro also provided contracts to local businesses for work on a trial pit. As an adjunct to the work of the WRPA, Toro has proposed to the federal and Western Australian governments that they support a training program based on renovating the historic Mine Manager's House at Wiluna. The program would offer training in home maintenance skills and development enterprise which could then be applied to provide ongoing maintenance services to the public housing stock in the region. A secondary outcome would be the upgrade of the property into an asset which could be used for a range of benefits to the community.

In seeking mining agreements with Traditional Owners, Toro has proposed the inclusion of specific provisions relating to training, employment and business development.

In working to provide more Aboriginal training, employment and business development opportunities, Toro would provide pre-employment, family and on the job mentoring to address the fact that in some families, there have been generations who have not participated directly in the workforce. Such mentoring can help at the individual and family level to establish greater compatibility between Aboriginal culture and the requirements for working in an industry in which all employees must comply with rigorous personal safety requirements.

Based on current estimates of employment requirements in mining in the Wiluna area, there are likely to be more places available for Aboriginal people than there are job-ready people to fill them. Toro would respond to this challenge through education and training initiatives and culturally-appropriate human resource arrangements to align Aboriginal people with their employment preferences. Consideration also would be given to the development of skills which can provide pathways to job advancement and promotion, and be used in other industry sectors after mine closure so that education and training programs offer sustainable employment opportunities.

A priority would be to train people interested in careers in the resources sector rather than seek to attract experienced operators from elsewhere. To do so would require programs to train and retain the necessary workforce in collaboration with government training and employment initiatives and other relevant providers. Using the precedent set by industry participation in the WRPA, Toro also would pursue opportunities for cross-company cooperation on workforce planning, training and recruitment.

Toro would establish a supply function within the company that would regularly notify local and regional businesses of contract opportunities associated with construction and mining. This would enable them to register Expressions of Interest subject to meeting certain acceptance criteria, and they would be invited to bid for work either as primary contractors or subcontractors.

As advised in its ERMP for mining at Centipede/Lake Way, Toro is committed to pursuing enhancement of community-based activities in a number of other ways including:

- Providing and sharing information about the environment of the region: The studies undertaken for the Centipede/Lake Way ERMP and subsequently for this PER add to the regional information base. As projects move from assessment and approval to implementation, they would generate further environmental and other information which could be shared by public reporting and other means. In this way, the presence of the mining industry in the region would generate environmental information that otherwise would not be available;
- Generating regional research: There is continuing potential for miners and project proponents to support research related to radiological impacts on the environment of the region;
- Protecting Aboriginal cultural heritage: Industry collaboration on cultural awareness would promote wider understanding of the importance of Aboriginal cultural heritage and could initiate business opportunities for Aboriginal groups in the provision of cultural awareness programs;
- Aboriginal community development: New projects would require mining agreements with Traditional Owners. Toro would collaborate with other industry participants with the aim of maximising the community development benefits to be delivered by these agreements; and
- Enhancing community infrastructure: Collaboration in the use of existing recreational and other infrastructure would improve its viability and encourage development of new infrastructure where gaps are identified.

19.7 Product Transport

An extensive discussion about how radiological impacts of the Proposal on people would be assessed and managed is provided in Section 14. The following discusses potential radiological impacts arising with transport of finished product as a result of implementation of the Proposal.

All UOC product would be transported from the processing plant adjacent to Millipede/Centipede, including product processed from ore mined at Lake Maitland. The method for and route of product transport are the same as that proposed for the already approved mining at Centipede and Lake Way (EPA Assessment 1819 and EPBC 2009/5174). While the method and route are the same, transport of product would occur over a longer period as a result of mining at Millipede and Lake Maitland, as well as at Centipede and Lake Way.

Toro's method of transporting UOC product would adopt procedures followed by uranium mines in South Australia and the Northern Territory for more than 20 years, which have resulted in uranium being transported by road and rail without incident.

UOC is classified as a Dangerous Goods Class 7 Material under the *Australian Dangerous Goods Code* and the transport of radioactive material is managed under the *Code of Practice for the Safe Transport of Radioactive Material*.

19.7.1 Regulation of Product Transport

The regulation of transport of radioactive material is undertaken by international, national, state and territory agencies working together. Over more than five decades, Australia has played a prominent role through the IAEA in the setting of international standards, policies and practices. In Australia, federal, state and territory government agencies involved in regulating the transport of radioactive material underpin their regulatory arrangements with periodic audits of performance by transport operators.

International Atomic Energy Agency

The IAEA has operated under the auspices of the United Nations since its establishment in 1957. In seeking to ensure the safe, secure and peaceful use of nuclear energy, the focus of the IAEA is on:

- Safety and security;
- Science and technology; and
- Safeguards and verification.

The IAEA has safety standards for international transport of radioactive materials known as *TS-R-1 – Regulations for the Safe Transport of Radioactive Material*. In addition to TS-R-1, the IAEA also produces supporting documentation including *Fundamental Safety Principles – Safety Fundamentals No. SF-1*. The regulations address all categories of radioactive material including ores and ore concentrates. They provide for marking, labelling and placarding, documentation, external radiation limits, operational controls, quality assurance, and notification of movement of radioactive substances across land and by marine and air transport.

Australian Government

The production, storage, transportation and ultimate export of uranium are regulated by the Australian Government under the *Nuclear Non-Proliferation (Safeguards) Act* 1987. Australia allows the export uranium only for peaceful purposes to countries that have signed the Nuclear Non-Proliferation Treaty (NPT) and have implemented a Bilateral Safeguards Agreement with Australia and the IAEA additional protocol on strengthening safeguards or, in the case of India, under a Civil Nuclear Cooperation Agreement (signed in September 2014) which remains subject to conditions that are currently being negotiated between government and the approval of federal parliament.

Australian Safeguards and Non-Proliferation Office

The Australian Safeguards and Non-Proliferation Office (ASNO), as an agency within the Department of Foreign Affairs and Trade, administers compliance with Australia's NPT obligations. ASNO monitors all international safeguards processes, reinforcing export permissions through bilateral safeguards and administrative arrangements with overseas nuclear regulatory authorities which have obligations to track all Australian-sourced material back to ASNO.

ASNO issues conditional permits to mine operators for the production, transportation, handling and storage of UOC. The permits detail a comprehensive range of responsibilities and requirements which include approved transport routes, appropriate security, maintaining documentary evidence and records of production, material transfers and export shipments.

Under these arrangements, Toro would be required to lodge a Transport Management Plan (TMP) with ASNO covering the procedures and processes required for the transportation of UOC from the mine site to point of export from Australia. ASNO, in conjunction with the relevant state or territory jurisdiction, would assess the plan. A strict requirement placed on a mine operator is the need to notify ASNO of any changes in conditions or incidents during transport of UOC.

ASNO also regulates transporters of UOC by land and sea, and export terminals. For shipments, carriers are approved liner cargo (i.e. container) or dedicated charter vessels that operate on shipping routes approved by ASNO from the Australian port of export to the overseas discharge port. On-carriage from the discharge port to a conversion facility is undertaken by an ASNO-approved nuclear freight forwarding service appointed by the Australian mine operator. Consignments are moved from the overseas discharge port to a convertor by road and rail. Confirmation of arrival at overseas transhipment, discharge and convertor is provided to ASNO for each consignment.

Department of Industry and Science

The *Nuclear Non-Proliferation (Safeguards) Act 1987* and the *Customs (Prohibited Exports) Regulations 1958*, pursuant to the *Customs Act 1901*, prohibit the export of UOC without approval by the responsible federal Minister, currently the Minister for Industry and Science. In administering this process, the Department of Industry and Science (DoIS) imposes strict requirements on mine operators. Each shipment of uranium requires approval from DoIS, as well as ASNO. In considering approvals, DoIS takes into account the relevant mine's compliance with conditions of approval for its operation imposed by the Australian Government.

Australian Maritime Safety Authority

The Australian Maritime Safety Authority (AMSA) is an Australian Government statutory authority with a charter to enhance efficiency in the delivery of marine safety, marine environment protection and other services to the Australian maritime industry.

The *Australian Maritime Authority Act 1990* establishes AMSA as the regulator for Australian maritime matters domestically and internationally. This includes the appointment of AMSA as the Australian competent authority covering all matters associated with the shipment of dangerous and hazardous materials (including Class 7 radioactive materials) covered by the *International Maritime Dangerous Goods Code*, as well as for setting standards applicable to inland transport covering mine to port of export.

AMSA also has responsibilities covering container packing, stowage, segregation of incompatible substances and documentation of UOC export consignments. AMSA has approved the use of the Cordstrap methodology for securing drums of UOC within shipping containers. Toro would require approval from AMSA for a packing plan, securing of drummed UOC within containers and other related approvals prior to the commencement of UOC export shipments.

Australian Radiation Protection and Nuclear Safety Agency

The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) publishes the *Code of Practice for the Safe Transport of Radioactive Material* which sets out the requirements for the transportation of UOC. The code mirrors the IAEA's *Regulations for Safe Transport of Radioactive Material*. The code is adopted in Australia in state and territory legislation and outlines the minimum requirements for the safe handling and transport of radioactive material. The requirements of the code, which is regularly reviewed, establish a system of radiation safety consistent with the recommendations of the International Commission on Radiological Protection. The latest edition of the code was approved by ARPANSA in 2014.

National Transport Commission

Under the *National Transport Commission Act 2003*, the National Transport Commission is responsible for regulatory reform to ensure safe, efficient and sustainable land transport covering road and rail.

The National Transport Commission is responsible for policy issues relevant to the transportation of UOC as follows:

- *Australian Dangerous Goods Code* (ADG Code) pursuant to the *Dangerous Goods Act 1995* and associated regulations including the *National Transport Commission (Model Legislation – Transport of Dangerous Goods by Road or Rail) Regulations 2007*; and
- Nationally consistent management of heavy vehicle driver fatigue and chain of responsibility in road transport according to the *Heavy Vehicle Fatigue Act 2006*.

The states and territories administer the ADG Code and the driver fatigue and chain of responsibility through the enactment of laws within the relevant jurisdiction.

Western Australian Government

Western Australian legislation applicable to the transport of UOC is the *Radiation Safety Act 1975* and the associated *Radiation Safety (Transport of Radioactive Substances) Regulations 2002*. The Act empowers the Radiological Council to issue licences and regulate the handling and receipt of radioactive materials. The regulations enact ARPANSA's *Code of Practice for Safe Transport of Radioactive Material*.

Western Australia requires transport operators to be licensed by the Radiological Council and to have established suitable radiation protection and associated procedures, such as transport management and incident response plans.

South Australian Government

The *Radiation Protection and Control (Transport of Radioactive Substances) Regulations 2003* (SA) impose conditions on the consignor, carrier, driver and storekeeper of radioactive substances and require seven days' notice to be provided prior to transporting radioactive substances within the state. The notice is to be provided to the Director, Radiation Protection Division, Environment Protection Authority. In practice, companies submit a monthly schedule to the South Australian Department of Premier and Cabinet advising the number of UOC containers and proposed shipment dates. Seven days prior to each scheduled shipment date, companies provide advice regarding the number of containers, names of driver, satellite telephone numbers for each vehicle and date and estimated times of departure and arrival. The Department of Premier and Cabinet then forwards this advice to relevant state government agencies, including the Environment Protection Authority.

The conditions imposed under the SA Regulations relating to the packing (in drums) and shipping (via dedicated shipping container) limit the type of transport vehicle that can be used to transport UOC to a semi-trailer or larger articulated vehicle ('restricted access vehicle'). The use of restricted access vehicles triggers provisions of the *Road Traffic Act 1961* which limit the road network on which such vehicles may operate.

The State Emergency Management Plan establishes the approach that must be followed in the event of an incident involving the suspected or actual leak or spill of UOC while in transit.

Northern Territory Government

Dangerous goods legislation and regulations impose licensing requirements to transport UOC by road or rail. Other Northern Territory legislation and regulations relevant to the transport of UOC and shipment from Darwin Port are:

- *Rail Safety (National Uniform Legislation) Act*;
- *Radiation Protection Act*;
- *Radioactive Ores and Concentrates (Packaging and Transport) Act*;
- *Darwin Port Corporation Act*; and
- *Darwin Port (Handling and Transport of Dangerous Cargoes) By-Laws*.

(Note – the information above about the legislative and regulatory arrangements in South Australia and the Northern Territory has been given for completeness. The transport of finished product arising from implementation of this Proposal in those two jurisdictions would be subject to separate assessment by those jurisdictions and is not part of the assessment and approvals being sought through submission of this PER).

19.7.2 Safety and Environmental Objectives – Finished Product Transport

The objectives of the product transport solution proposed by Toro are:

- Consistent with the ALARA principle, to limit radiation exposure to members of the public, transport workers and emergency service responders to less than 1 millisievert per year (mSv/a) over and above background radiation exposure; and
- To minimise any potential adverse effects on people or the environment associated with transport of finished product.

Potential Impacts

The potential impacts and risks from transport of finished product are:

- Increased noise and traffic hazard;
- Radiation exposure to members of the public and workers; and
- An accident during transport resulting in release of radioactive material from containment.

Toro has undertaken studies to inform the preparation of the PER as follows:

- Reviewed transport routes and options;
- Assessed transport alternatives and routes and associated risks; and
- Modelled potential radiation exposure to members of the public and transport workers.

Radiation Impacts Arising from Product Transport

For members of the public, the dose limit is 1 mSv/a above natural background levels. The only potential exposure during routine transport is to gamma radiation in close proximity to UOC consignments being transported. Gamma radiation doses reduce rapidly as the distance from the source increases.

Toro's proposed road transport solution considered three possible radiation exposure scenarios to gamma radiation based on up to five containers carried by up to three trucks travelling together once per month between the processing plant near Wiluna and Port Adelaide. This transportation frequency would apply to product from Millipede and Lake Maitland, as well as Centipede and Lake Way. The scenarios considered were:

i) A member of the public at the edge of the road while the monthly consignment passes: If the person was standing on the footpath each time the three trucks passed, the total dose over 12 months would be 0.012 mSv above background;

ii) A member of the public travelling behind a UOC consignment for one hour up to four times a year: The total dose over the year would be 0.06 mSv above background; and

iii) A truck driver transporting UOC: Assuming the driver did twelve round trips between the mine site and Adelaide in a year, the total maximum dose would be 0.4 mSv above background. Truck drivers would be regularly monitored for radiation as part of Toro's occupational health and safety procedures.

During public consultation, it was suggested to Toro that transport of UOC presented the same risk of contamination and other impacts to the community as the transport of lead which had caused a suspension of lead mining operations near Wiluna for a period of time.

Transport of UOC as proposed by Toro is not comparable with the form of lead transport which raised community concerns.

UOC is required under National and International guidelines to be transported in sealed steel drums carried in sealed shipping containers which provide dust protection. The packaging sequence prior to product leaving the mine site would be as follows:

- Packed in Industrial Packaging Standard 1P-205 L steel drums (up to 64 drums per container);
- Secured and packed using an acceptable design and strapping approved by AMSA; and
- Loaded and locked in a 20 ft. container lined with plastic sheeting and labelled showing carriage of radioactive material.

As a result of these packaging procedures, and the fact that the product is solid and not amenable to dusting, no uranium product losses are predicted during transportation.

During public consultations, Toro was requested to consider regular monitoring of radiation levels along the route for product transport. Such monitoring has been determined to be not viable as the variability in natural radiation levels means that an increase in radiation due to product transport would be undetectable. Radiation levels on the transport route would only increase in the extremely unlikely event of a spillage of UOC. With its packaging in sealed steel drums and shipping containers, the risk of contamination during normal transport is negligible. In the event of any spillage of UOC, monitoring would be undertaken of the incident area to ensure that appropriate clean-up and removal had been implemented.

Finished Product Transport Route

In evaluating finished product transport options, Toro commissioned a study which assessed impacts and risks. The study was based on the following route:

- Purpose-built private road from processing plant (adjacent to Millipede/Centipede) to Goldfields Highway;
- Goldfields Highway to Norseman via Leonora, Menzies, Kalgoorlie-Boulder (on eastern bypass road) and Kambalda;
- Eyre Highway from Norseman to Port Augusta; and
- Princes Highway (National Route 1) from Port Augusta to Port Adelaide.

The assumption was that there would be a monthly consignment of UOC from the mine site transporting up to five 20 ft. containers of UOC via two prime movers with double trailers (double road trains) and one prime mover with a single trailer. At all times, a minimum of two trucks would travel together between the mine site and Port Adelaide.

A journey plan for a dual driver combination for the monthly movement for three vehicles travelling together was developed based on a round trip from Adelaide to the Wiluna mine site and return (Table 19.5). The journey would require a total travel time (including load/unload) of 90.5 hours for a dual driver combination travelling at an average speed of 80 km/h to complete a round trip of 5461 km. This includes fatigue management rest breaks and one overnight break at the Toro accommodation camp.

Table 19.5: Overview of transport schedule (journey plan)

Direction and day	Route	Distance (km)	Duration (hours)	Rest time (hours)	Running clock	Day	Break and Fuel
Inbound					8.00 am	Monday	Start
Day 1	Adelaide-Kimba	460	6.0	0.5	2.00 pm	Monday	Refuel Port Augusta and rest, check tyres
Day 1	Kimba-Ceduna	313	3.5	0.5	5.30 pm	Monday	Rest and check tyres
Day 1	Ceduna-Border Village	450	5.0	0.5	10.30 pm	Monday	
Day 2	Border Village-Norseman	720	8.0	1.0	6.30 am	Tuesday	Refuel Norseman+breaks on route and truck stops
Day 2	Norseman-Kalgoorlie	188	2.5		9.00 am		
Day 2	Kalgoorlie-Wiluna	566	7.0	0.5	3.00 pm		
Outbound	Overnight rest			14.5			Room rest at mine site
Day 3	Load/depart mine site		2.0		8.00 am	Wednesday	Loading commences 6.00 am
Day 3	Wiluna-Kalgoorlie	566	7.0	0.5	2.00 pm		Rest and check tyres (outside City of Kalgoorlie-Boulder)
Day 3	Kalgoorlie-Norseman	188	2.5		4.30 pm		Refuel Norseman and check tyres
Day 3	Norseman-Madura	530	6.0	0.5	10.30 pm		
Day 4	Madura-Port Augusta	1140	14	2.0	12.30 pm	Thursday	Rest breaks and tyre checks Mundrabilla and others
Day 4	Port Augusta-Adelaide	310	3.5	0.5	4.00 pm	Thursday	Refuel Port Augusta and rest, check tyres
Day 4	Unload and return to depot	30	2.0		6.00 pm		Finish
	Total	**5461**	**69.5**	**21**			

Toro would prepare the following plans for the approval of the relevant jurisdiction/s to satisfy all regulatory requirements relating to the transport of finished product:

- Transport Management Plan;
- Emergency Response Plan to align with emergency services in the relevant jurisdiction/s; and
- Security Management Plan in accordance with the requirements of ASNO.

The Transport Management Plan (TMP) would require the approval of the Federal and Western Australian governments and be subject to their regulation. Transport of finished product in other jurisdictions would also comply with the TMP.

The TMP would establish the framework for operational control systems and procedures (i.e. day to day aspects) for the safe, efficient and incident-free transport of product between the mine site and the port of export.

The TMP would be aligned with the transport service provider and have an emphasis on a strong safety culture covering:

- Regulatory compliance;
- Comprehensive operational procedures;
- Appropriate packing and securing practices;
- Correct and valid licences from relevant regulators;
- Approved transport routes;
- Correct documentation for all movements; and
- Audits, assessments and regular reviews.

A risk assessment completed for the proposed transport solution and mitigation and control measures is summarised in Table 19.6.

The main risks identified for finished product transport were:

- Injury to personnel during loading;
- Road transport safety;
- Loss of control leading to loss of containment; and
- Security risks.

Overall, the assessment determined the risk rating to be low. It also determined that road transport with dual driver-road transport combination between Wiluna and Adelaide was the preferred solution on the basis of:

- Shortest road distance to travel to available shipping;
- Minimising interaction times with the public and communities along the proposed route and connecting with established road (and rail) routes in South Australia;
- Minimising product handling; and
- No impacts of tropical cyclones which can close the road route to northern Australian destinations.

Table 19.6: Summary of transport risks

Risk Issue	Description	Causes	Likelihood	Consequence	Mitigation and Controls	Residual Risk
Injury to Personnel During Loading and Unloading	Injury to personnel during loading and unloading	Mobile plant/light vehicle/truck and human interaction Equipment failure Fit for work Operator error/rule breach	Low	Low - Medium	Management and contractual controls Inspection and preventative maintenance systems Training for securing loads	Low
Road Transport Safety	Unpaved road incidents • Collision • Rollover/hit infrastructure • Leaving road Paved road incidents • Collision • Rollover/hit infrastructure • Leaving road	Accident or collision due to: Vehicle congestion in towns/on route Environmental conditions (poor visibility such as sun/fog, wet, bushfires) Condition of road (wet, slippery, black spots) Fatigue/fitness for work Level crossing interaction Rule violation	Low	Low - Medium	Preferred contractor, audits, licensing compliance Transport Management Plan, driver training for unsealed road Regular road maintenance to reduce dust and maintain road condition Preferred contractor, audits, licensing compliance Compliance with chain of responsibility/fatigue management regulations	Low

Risk Issue	Description	Causes	Likelihood	Consequence	Mitigation and Controls	Residual Risk
Loss of Control Leading to Loss of Containment	Occurrence during transport	Accident or collision Fatigue Overloading Road conditions Weather conditions Failure to follow systems or procedures	Low	High	Packaging methods (drums secured in containers) Preferred contractor, audits, licensing compliance Safety and Incident Management Plan, Emergency Response Fatigue Management Program, Chain of Responsibility Administrative procedures (in-vehicle and on-route monitoring systems, pre-start and packaging/vehicle loading audits)	Low - Medium
Security Risks	Unauthorised access Malicious intervention	Third Party intervention Vandalism/sabotage Theft	Low - Medium	High	Transport and Security Management Plans Police intervention Driver training Service provider management Federal government intervention Monitoring for protestor activity	Low - Medium

In the current phase of Australian uranium mining since the early 1980s, there have been no transport-related incidents involving the spillage of product on the open road. This has included the movement of almost 90,000 t of UOC for export over the past 10 years, shown in Table 19.7.

Table 19.7: Annual exports of UOC from Australia

Year	Tonnage of UOC shipped
2004/5	11,215
2005/6	10,233
2006/7	9518
2007/8	10,140
2008/9	10,114
2009/10	7555
2010/11	6950
2011/12	6918
2012/13	8391
2013/14	6701

Source: ASNO Annual Reports

Emergency Response

Toro has engaged in discussions about emergency response planning and procedures in the event of an incident on or off site with federal, Western Australian, South Australian and Northern Territory government agencies, including emergency services. The response to any incident would be supported by:

- A Toro Emergency Response Plan communicated to the relevant regulatory authorities and emergency services;
- Appropriate training for the drivers of trucks carrying UOC ensuring alignment with local conditions;
- Appropriate training for emergency services personnel;
- The availability of clean-up equipment;
- Qualified specialists on call at all times; and
- Agreements with local service providers to participate in the response, containment and recovery phases.

Toro has participated in industry initiatives to involve regionally-based government and commercial agencies in discussions about transport management. Should this Proposal be approved, and prior to the commencement of production, Toro would establish and coordinate training programs across all relevant agencies likely to be involved in the transport of UOC to include:

- Radiation training and awareness for transport workers involved in transporting, handling, storing or loading UOC;
- Radiation training and awareness for emergency services (State Emergency Service, fire brigade, ambulance service and volunteer emergency services) or other agency personnel involved in the initial response to any incident; and
- Emergency response and clean-up of any spilt UOC for emergency services personnel.

The training would focus on providing participants with awareness regarding:

- Requirements relating to the safe handling, storage and transportation of radioactive materials;
- The characteristics of UOC; and
- Radiation safety protection requirements, first aid and personal safety.

In the extremely unlikely event of an accident and the escape of product from its steel drum and shipping container, Toro would activate the Emergency Response Plan developed in conjunction with the relevant government authorities and emergency services. A response kit carried in the truck convoy would be used in the immediate containment of any spilt UOC through the use of tarpaulins and other related equipment, including hazard signs to alert approaching traffic. The continuing response would involve police assuming overall responsibility with fire, ambulance and other emergency services as responders for their specific areas of responsibility, as required. Toro would provide technical support and advice to these services in the handling of UOC. Until the arrival of police and emergency services and Toro personnel, truck drivers with the required training would contain any spilt materials and prevent access to the incident site. The Emergency Response Plan would focus on:

- Rescuing any injured personnel and providing any emergency first aid/medical attention required;
- Evacuating non-essential personnel and members of the community;
- Using respiratory protection, protective clothing and eyewear to reduce the possibility of inhaling radioactive material;
- Minimising the time spent nearby and maximising the distance to any spilt product;
- Controlling any fire and other common consequences of transport incidents;
- Identifying any associated hazards (e.g. other dangerous goods such as fuel spills, electrical sources) and establishing a controlled cordoned-off area;
- Controlling and preventing any additional spread of radioactive contamination;
- Recovering the radioactive material, packaging and transport equipment;
- Quarantining people who may have come into contact with the material, decontaminating personnel and recovering contaminated material (e.g. personal protective equipment, clothing) for correct disposal;
- Decontaminating equipment in preparation for rail and/or road transport; and
- Decontaminating and restoring the surrounding environment to an acceptable standard, including verification monitoring.

Mutual aid arrangements would be established with local services to maximise support in the event of an incident with the aim of ensuring the ready availability of assistance in the response, containment and recovery phases.

Security

Toro would lodge a Security Plan for the consideration of ASNO that would have the following objectives:

- Deter, detect and delay unauthorised access during storage or transport of finished product;
- Defeat any attempted theft or malicious acts during storage or transport of product; and
- Respond appropriately, allowing immediate recovery or contingencies to commence promptly.

Through procedures and instructions, the Security Plan would identify measures to achieve the above objectives and identify how those measures would be periodically reviewed and communicated to all relevant parties associated with the transport of UOC.

During finished product transport, security measures would include:

- Approved transport management plans with a minimum of two trucks travelling together at all times along approved and designated transport routes with stops only for necessary operational requirements;
- Drivers following established communication protocols throughout the journey, including regular reporting of whereabouts/status; and
- Continuous monitoring of the location of each vehicle transporting finished product.

In conjunction with ASNO and the responsible government agencies in Western Australia, security assessments would be undertaken covering all credible risks and threats as part of the approval process for transport of product.

Road Safety

Using the traffic count in Table 19.8 and the point on the Goldfields Highway north of Mt Keith as the base where the count is an average 60 vehicles per day, traffic movements would increase by 0.16% as a result of Toro's product transport. At the count point north of Kookynie Road between Leonora and Menzies, Toro's product transport would increase the daily volume of traffic by 0.02%. At the count point south of the Gidji Roaster near Kalgoorlie, it would increase by 0.009%.

Table 19.8: Goldfields Highway traffic volumes (2013–2014)

Count Location	Annual Average Daily Traffic	Heavy Vehicles
North of Mt Keith	60	53%
North of Yakabindie Road	160	55.5%
North of Old Agnew Road	470	37.2%
North of Kookynie Road	370	44.3%
South of Yundaga Road	410	46.1%
South of Broad Arrow-Ora Banda Road	730	43.4%
South of Gidji Roaster Access Road	1080	29.7%

Source: MRWA (2015).

From this information, therefore, the additional trucks on the road as a result of movement of product from this Proposal would not have any significant impact on the existing volumes of traffic on the same route.

The most recent available national crash statistics are for the 12 months to the end of December 2014 (BITRE, 2014). During that period, there were 100 fatal crashes of articulated trucks, resulting in 114 fatalities Australia wide. Of these, five fatal accidents (five fatalities) occurred in Western Australia and 10 fatal crashes (12 fatalities) occurred in South Australia.

Road fatalities currently occur in Western Australia at the rate of 0.6 per 100 million vehicle kilometres travelled (Office of Road Safety, 2014). On an annual basis, the cumulative distance travelled on the Western Australian road network by trucks transporting product from the Wiluna Project would be 108,540 km. Based on current rates, this could result in one fatality every 1530 years. Accordingly, the likelihood of a fatal crash involving a truck carrying UOC is assessed as extremely low.

Road use during the Construction and Operational Phases

Millipede

Due to the proximity of the Millipede deposit to Centipede, no additional major pre-fabricated infrastructure would need to be transported to site to enable mining at Millipede. The construction and operational workforce would be accommodated on site at facilities to be established to support already approved mining at Centipede and Lake Way (EPA Assessment 1819 and EPBC 2009/5174).

The transport volumes for processing reagents and other commodities for the operational phase would be approximately 35,500 tpa. These would be transported from Perth to Wiluna via Kalgoorlie. During the operational phase, the increase in vehicle numbers associated with the implementation of this Proposal would not have a significant effect on traffic flow.

Lake Maitland

Some pre-assembled modules would be constructed (or partly-constructed) off site and transported to site for final assembly and installation to provide administration offices, the accommodation camp and related infrastructure. The movement of these items would occur along the Perth-Leinster transport route via Kalgoorlie. No temporary road closures or the holding of traffic at the roadside would be required to accommodate these loads.

Toro expects that the maximum operational workforce based at Lake Maitland would be approximately 50 people, to be accommodated on site. Accordingly, any increase in vehicle numbers associated with mining at Lake Maitland would not have a significant effect on traffic flow.

19.8 Crime and Anti-social Behaviour

Based on the experience of other mining towns, the SIA identified a concern in the Wiluna community that the location of accommodation in the township for mine employees and contractors may result in an increase in anti-social behaviour influenced by excessive alcohol consumption. This is one of the reasons Toro has decided to locate the accommodation village to support mining at Millipede, Centipede and Lake Way about 30 km south of Wiluna. To monitor and address any impacts of Toro’s presence on crime and safety in the community, Toro would:

- Liaise regularly with local police and the shire to monitor any changes in crime trends;
- Conduct an annual community survey, monitoring community perceptions of crime and safety; and
- In the event of any significant change to trends or perceptions on account of Toro’s presence in the community, initiate action to address them.

Toro would also:

- Apply ‘Designing Out Crime’ principles to the management of workforce accommodation arrangements; and
- Consult on a regular basis with Traditional Owners and the local shire and police about crime and safety issues.

20 ENVIRONMENTAL MANAGEMENT FRAMEWORK

This section outlines the process and environmental management documentation required for ensuring that the PER conditions of approval, commitments, management measures and monitoring, reporting and audit requirements are implemented at the appropriate time should the Proposal be approved.

20.1 Management and Monitoring Plans

In planning for the environmental management of the Wiluna Uranium Project and its extension, Toro has prepared a range of Management and Monitoring Plans which are attached as appendices of this PER. They describe management actions to be implemented during the construction, operational, closure and rehabilitation phases of the Project. These management actions have been developed to comply with conditions of approval, avoid or mitigate potential impacts and to protect conservation and biodiversity values. The relevant plans are:

- A Compliance Assessment Plan (Appendix 5) to indicate the frequency of compliance reporting; the approach and timing of compliance assessments; the retention of compliance assessments; the method of reporting of potential non-compliances and corrective actions; the table of contents of compliance assessment reports; and public availability of compliance assessment reports.
- A Vegetation and Flora Monitoring Plan (within the Environmental Management Plan - Appendix 4) to include identification of potential impact monitoring and control sites; design of a survey to acquire baseline biotic and environmental data; definition of health and abundance parameters; definition of critical correlative environmental parameters, including groundwater drawdown; definition of monitoring frequency and timing; identification of criteria to measure decline in health; and definition of trigger levels and management responses required should a trigger level be exceeded.
- A Groundwater Dependent Vegetation Research Plan (within the Environmental Management Plan – Appendix 4), including a monitoring plan, to investigate the environmental water requirements of groundwater dependent vegetation units potentially impacted by Toro's Proposal.
- A Groundwater Drawdown Monitoring and Management Plan (within the Environmental Management Plan - Appendix 4) to limit potential impacts on stygofauna, *Tecticornia* dominated vegetation and inferred groundwater dependent vegetation through design and implementation of a suitable groundwater barrier system around mining areas; including trigger levels for groundwater drawdown levels; design and implementation details of a barrier system to control groundwater drawdown so that the trigger levels are not exceeded; and implementation of the outcomes of the Groundwater Dependent Vegetation Research Plan.
- A Surface Water Environmental Management Plan (within the Environmental Management Plan - Appendix 4) to include operational procedures that ensure water flow through creek line diversions made from previous workings does not become contaminated by contact with workings; and a monitoring regime for surface water quality using ANZECC (2000) (and any subsequent approved revisions) water quality criteria or background for assessing water quality changes.
- A Dust Environmental Management Plan (within the Environmental Management Plan - Appendix 4) to include a dust monitoring plan; procedures to manage dust during periods of high winds likely to lead to dust storms; and contingency plans for the management of dust should mining involve blasting.

- A Stygofauna Monitoring Plan (within the Environmental Management Plan - Appendix 4) to include a survey regime for stygofauna; and a monitoring regime for water quality and quantity in particular calcretes.
- A Cultural Heritage Management Plan (Appendix 8) to include arrangements for the management and protection of sites of cultural heritage significance.
- A Fire Management Plan (within the Environmental Management Plan - Appendix 4) to include management measures such as appropriate storage of combustible materials; establishment of fire breaks in operational areas; and the conduct of drills to manage potential fire outbreaks.
- A Noise Management Plan (within the Environmental Management Plan - Appendix 4) to include actions to minimise potential impacts to fauna, with all vehicles, plant and machinery to be operated within appropriate noise standards and relevant guidelines.
- A Radiation Management Plan (Appendix 6) and Radioactive Waste Management Plan (Appendix 7) to include management measures such as appropriate storage, handling and transport of material; monitoring programs for levels of radioactive material around sensitive sources (human and environmental); and appropriate waste storage.
- A Waste Management Plan (within the Environmental Management Plan - Appendix 4) (not including radioactive materials) to include management measures such as waste segregation to assist in the appropriate management of waste streams; implementation of a site recycling program; tracking waste types and volumes; monitoring of waste storage areas.
- A Transport Management Plan (Appendix 9) to include appropriate storage, handling and transport of product; an emergency response plan; vehicle maintenance; and safety checks.
- A Mine Closure and Rehabilitation Plan (Appendix 3) to include progressive rehabilitation; identification of closure obligations and commitments; collection and analysis of closure data; post-mining land use and closure objectives; identification and management of closure issues; development of completion criteria; financial provision for closure; and closure monitoring.

20.2 Environmental Management System

To assist Toro staff, contractors and visitors to site to comply with all legislative and regulatory requirements, and to enable appropriate management of potential environmental impacts, Toro would implement an Environmental Management System (EMS) that would cover all aspects of Toro's operations.

An EMS is based upon the Plan-Do-Check-Act cycle, which flows from the corporate environmental policy. Utilising this approach supports Toro's commitment to continuous improvement.

The EMS would be one component of Toro's integrated management system to ensure all elements of its operations work together as one unit. This means all sections of the company would have a consistent set of documentation, policies, procedures and processes.

Toro would seek an AS/NZS ISO 14001:2004-certified EMS to manage environmental issues for the Extension to the Wiluna Project. This is an international standard which identifies the requirements for an EMS:

> 'An EMS meeting the requirements of ISO 14001:2004 is a management tool enabling an organization of any size or type to:
>
> - Identify and control the environmental impact of its activities, products or services, and to
> - Improve its environmental performance continually, and to
> - Implement a systematic approach to setting environmental objectives and targets, to achieving these and to demonstrating that they have been achieved.' (www.iso.org)

The management and monitoring plans provided as appendices to this PER consolidate the commitments, management measures, objectives, assessment criteria and monitoring requirements from the PER into a stand-alone document that can be regularly reviewed and updated.

Toro's EMS would incorporate:

- Roles and responsibilities;
- Training and competence;
- Workforce communications and reporting (including public reporting);
- Monitoring;
- Compliance register;
- Performance measures (audits);
- Review (performance and compliance assessment);
- Management response; and
- Records and document control.

20.3 Environment Policy

Toro has adopted the following environment policy for the Wiluna Project and its extension.

Environment Policy

Toro Energy Limited is committed to the welfare of all employees, contractors and the local communities in which we operate. Our goal is to have an injury free workplace with zero harm to our personnel, business, environment and community. We strive to support the principles of environmental sustainability and minimise potential effects to the environment.

To deliver on this commitment, we will:

- Operate in compliance with all relevant environmental laws and regulations, and where possible, endeavour to exceed those standards;
- Identify and manage all risks and hazards;
- Create a culture where compliance with all relevant environmental laws and regulations is a part of our daily business;
- Uphold ethical business practices and set appropriate and measurable environmental objectives and targets;
- Manage and minimise all waste streams;
- Set and achieve targets that promote efficient use of resources and include reducing and preventing pollution;
- Promote protection of the environment through all phases of our operations, from exploration through to mining, and eventually decommissioning;
- Provide appropriate training and support to all employees and contractors to enable them to meet their environmental obligations;
- Work with local Indigenous groups and communities to achieve mutually agreeable project outcomes; and
- Aim to continually improve on our environmental performance through regular review of performance against set targets, and the reporting of such reviews.

20.4 Management Accountabilities (Roles and Responsibilities)

Senior management would be accountable for organisational processes and activities that have an impact on the environment.

Senior managers would give their full commitment to the audit process (both environmental and radiation). Management would ensure that all staff and contractors who may be affected by an audit would be informed about the process to allow audits to be credible.

Provisional site roles and responsibilities of Toro employees and contractors responsible for the implementation of the management plans are shown in Table 20.1.

Table 20.1: Roles and Responsibilities

Role	Responsibility
Mine Manager	On-site management and responsibility for the Project, Toro employees and contractors.
Occupational Health, Safety and Environment (OHS&E) Manager	Induct staff, contractors and visitors to site about the requirements of the management plans.
Environment Manager	On-site responsibility for implementation of environmental policies, procedures and systems; Ensure Compliance Register is implemented and maintained; Ensure compliance with all environmental policies, procedures and systems by contractors, Toro staff and visitors to site; and Inform relevant regulatory authority personnel in the event of a reportable incident (within 24 hours or as otherwise required).
Environmental Officer	Maintain and update procedures and forms for documenting environmental incidents, non-compliances and complaints; Record all non-compliances, incidents and complaints on the Compliance Register; Correct all non-compliances to the satisfaction of the OHS&E Manager; Report on implementation and effectiveness of corrective actions; Carry out environmental audits and ongoing monitoring to verify compliance; and Liaise with stakeholders.
Radiation Safety Officer	Maintain all radiation safety-related systems, procedures, data and equipment in order to ensure all legal obligations are met; Collect and interpret on-site data relating to radiation safety; Maintain effective relationships with regulatory agencies; Ensure all statutory reporting requirements are met through the development of reports for internal distribution and submission to regulatory agencies; Provide expert advice and leadership to management on all issues with respect to radiation; and Provide and deliver training in radiation safety for all staff and contractors.
Contractors	Carry out work in accordance with the management plans; Obtain and hold on site any documentation needed to undertake work; and Train staff (as required) so that work is carried out to comply with requirements of the management plans.
All Other Toro Personnel and Site Visitors	Comply with all relevant site procedures and policies.

20.5 Planning/Risk Assessment

Toro has undertaken a series of risk assessment workshops. To date, risk assessments have been used to identify and prioritise potential Project-related environmental and other impacts. The risk assessment process is based upon the framework stated in AS/NZS 4360:2004 with the guide HB 203:2012. These assessments have allowed Toro to focus on aspects which may represent a higher level of risk.

Issues raised from the public consultation process, including with Traditional Owners, and from various environmental surveys and modelling studies, have provided input to the risk assessment workshops.

Toro recognises that by developing management controls (to protect conservation and biodiversity values) and implementing ongoing monitoring of identified impacts, residual risks from Project activities would be reduced.

Risk assessment and management through the construction, operational, closure and rehabilitation phases would be an ongoing process, in line with Toro's commitment to continuous improvement.

20.6 Training and Competence

All Toro staff and contractors would have the appropriate training, knowledge and skills required to perform their duties in accordance with Toro policies, procedures and relevant legislative and regulatory requirements.

Employees, contractors and visitors to site would undergo an induction process, which would include awareness and appreciation of Toro's management systems and policies.

Inductions would be performed by a suitably qualified person, such as the OHS&E Manager. All inductees would be required to complete and obtain a satisfactory result on an induction questionnaire. The OHS&E Manager (or delegate) would retain the completed induction questionnaires and a record of all personnel who have completed the induction process.

Training would be provided by Toro on an as-needs basis to staff. Contractors would be responsible for providing appropriate training to their employees based on Toro's standards and requirements.

20.7 Communications and Reporting

Toolbox meetings would be held regularly to communicate any environmental incidents (as they arise), new environmental standard operating procedures, issues or management strategies to all staff and contractors. Signage, where appropriate, would be established to provide information to Toro employees, contractors and visitors to site.

Ongoing training (as required) for Toro employees and contractors would also be a forum for ongoing communications.

An incident reporting procedure would be implemented for all Toro employees and contractors.

The Environmental Policy, procedures and standard forms would be readily accessible and available to all Toro employees, contractors and visitors to site.

Toro would publicly report on its operational, environmental and social performance on an annual basis and have an external audit of such reporting every three years. Toro would provide immediate notification to any affected community or stakeholder of any environmental incident. General community and stakeholder consultation would be ongoing and in accordance with the Toro's Community and Stakeholder Consultation Program.

20.8 Monitoring

Monitoring activities would continue throughout the life of the Project, including:

- Internal audits and inspections;
- Internal Compliance Register review;
- External audits and inspections;
- Surveys (such as weed or fauna surveys);
- Water quality monitoring; and
- Incidental observations.

All audits, inspections, surveys and water quality monitoring would be performed by appropriately qualified and experienced personnel. Audit and inspection frequency would be determined in the management strategy for compliance. All audit and inspection results would be reported directly after the audit/inspection has been completed. An audit/inspection report would be generated and stored within the Toro environmental database. The report would generate a corrective action procedure (where non-compliance or an incident had been recorded), and subsequent audits would review the recommended corrective actions.

20.9 Compliance Register

As part of Toro's commitment to compliance with all legislative and regulatory requirements and to continuous improvement, a Compliance Register would be an integral part of the Toro EMS. This Compliance Register would include:

- All relevant legislation and other regulatory requirements;
- Lease conditions (permits and approvals);
- Toro's supporting documentation (policies and procedures); and
- Conditions for closure and rehabilitation.

This Compliance Register would be an internal document from which any reporting requirements would be generated.

20.10 Audits

Environmental audits would be conducted by internal and external auditors. Toro would implement an internal (or self) audit periodically, annually at a minimum. Audit schedules may change as the Project develops (e.g. internal audits may occur at a six-monthly interval, external audits may only occur every second year). All internal environmental compliance audits would be undertaken by competent auditors, who would be registered members of RABQSA International or a similarly accepted professional certification body.

Environmental audits require a structured approach, based on established protocols and audit criteria. Toro's internal audits would be holistic, covering all activities relating to the environmental impacts of the Project. Environmental audits would include radiation assessments where applicable to environmental factors. Compliance review would be a principal component of an environmental audit.

As part of Toro's commitment to continuous improvement, each management plan would be subject to internal review every five years, or when relevant new information became available. All management plans, once reviewed, would have the status change altered on Toro's document control system.

20.11 Management Response

A management response to matters of environmental compliance would be triggered by non-compliance incidents, audit report results and any other monitoring results (e.g. flora or fauna survey report results).

20.12 Records and Document Control

Toro would implement and maintain a database for management of environmental data. This database would also include Toro's environmental policies, procedures, compliance register and audit information.

Effective document control requires documentation to be approved by authorised personnel prior to use, and there must be review and updating as necessary (and re-approval). To provide continuity, the specified document owner would be the Environmental Officer, who would monitor the currency and appropriateness of documentation content. Changes to documents would be clearly identified. Relevant versions would be available at points of use, and all documents would be clearly identified. A controlled archiving system would be implemented to deal with obsolete documents.

20.13 Community and Stakeholder Engagement

The outcomes of the Project's performance and the effectiveness of the environmental management framework would be communicated on a regular basis to interested communities and stakeholders through the Community and Stakeholder Consultation Program outlined in Section 4.3.8. Regular consultation would be maintained with Native Title Holders and Claimants.

20.14 Principles of Environmental Sustainability and Protection

In planning the Project, including for its extension, Toro has given careful regard to the principles of environmental protection. In particular, the principles of intergeneration equity, waste minimisation, best practice management and eco-efficiency are already reflected in design decisions and in the Project alternatives considered by Toro. The field and laboratory studies, modelling and other investigations undertaken for the preparation of this PER were designed to take account of the precautionary principle and also to provide a robust basis for giving practical effect to the principle of biodiversity conservation.

Implicit in its assessment of the impacts and benefits of the Project is that Toro would comply with all legal and regulatory obligations and its own policies. The management measures Toro has proposed to meet its commitments would be further refined or amended as a result of improved practices or technological advances with time, as contemplated by its environmental management framework.

A summary of how key environmental protection principles are embodied in the Extension to the Wiluna Uranium Project is provided in Table 20.2.

Table 20.2: Environmental Protection Principles

Principle	How Addressed	Further Actions and Activities of Toro
Environmental, Social and Economic Considerations		
• Environmental, social and economic factors should be taken into account in government and other sectors' decision-making processes, with the objective of improving community well-being and the benefit of future generations. • The environmental practices and procedures adopted should be cost-effective and in proportion to the significance of the environmental risks and consequences being addressed.	Toro has carried out formal risk workshops. The outcomes of this work have been used to establish an acceptable level of understanding of environmental risk and to allocate resources and effort to the management of all Project risks and to outcomes which will benefit the community now and into the future.	• Environmental Management • Radiation Management and Protection • Safety in Product Transport • Socio-economic Impacts and Benefits
Precautionary Principle		
• If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. • Decision-making should be guided by: - a careful evaluation to avoid serious or irreversible damage to the environment wherever possible; and - an assessment of the risk-weighted consequences of the options.	Extensive studies have been undertaken to improve knowledge of the condition and behaviour of environmental systems in the Project area. The impact assessments carried out after this additional work considered the level of certainty attached to each impact assessment. Management Plans provided as an appendix to this PER define sensitive and robust monitoring approaches and management trigger levels to enable detection of and response to environmental changes resulting from Toro's activities before there is a significant risk of extensive or irreversible harm.	• Environmental Management • Biophysical Baseline Studies • Biophysical Environmental Impact Assessments

Principle	How Addressed	Further Actions and Activities of Toro
Intergenerational Equity		
• The present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations. • This implies that the present generation has a stewardship role in the maintenance of natural capital and a responsibility to ensure its wise use.	The Project would be implemented in accordance with all relevant regulatory requirements and adopt best practice design and management to the extent practicable. Toro would make adequate provision for site decommissioning and rehabilitation, and adopt designs and operational practices that would ensure that any resources required for environmental management do not accrue disproportionately in the post-closure period.	• Integration of Land Disturbance and Rehabilitation • Minimising Land Disturbance and Progressive Rehabilitation to Original Landform • Mine Closure and Rehabilitation Plan
Conservation of Biological Diversity and Ecological Integrity		
• Biological diversity (the variety of all life forms: the different plants, animals and microorganisms, the genes they contain, and the ecosystems of which they form a part) is considered at three levels: genetic diversity, species diversity and ecosystem diversity. • Biological diversity is best conserved in situ. • The close, traditional association of Western Australia's indigenous peoples with components of biological diversity should be recognised. • Although all levels of government have clear responsibility, the cooperation of conservation groups, resource users, Indigenous peoples, and the community in general is critical to the conservation of biological diversity.	Appropriate baseline studies have been conducted to enable the potential impacts of the Proposal to be understood at a genetic, species and ecosystem level. Toro has actively sought input from a range of stakeholders, including Traditional Owners, in conducting its baseline studies. Where there are multiple options for location or layout of Project plant or infrastructure, Toro has sought to adopt the option which poses the lesser risk to biological diversity. The design and sequencing of mine development would aim to minimise land clearing.	• Biophysical Baseline Studies • Biophysical Environmental Impact Assessments • Consultation with Traditional Owners • Aboriginal Cultural Heritage Management Plan

Principle	How Addressed	Further Actions and Activities of Toro
Shared Responsibility		
• Protection of the environment is a responsibility shared by all levels of government, industry, business, communities and the people of Western Australia. • The decisions and actions of people in their daily lives, when multiplied at the community level, are responsible for many of our diffuse source environmental impacts. Consequently, positive changes in behaviour at the individual level can cumulatively improve the management of these impacts.	The efficient development of primary sources of uranium will contribute to global diversification of power sources and reduce dependency on hydrocarbon fuels which give rise to greenhouse gases.	• Project Justification and Objectives • Collaboration with Regional Partners to Achieve Social Objectives
Product Stewardship		
Producers and users of goods and services have a shared responsibility with government to manage the environmental impacts throughout the life-cycle of the goods and services, including the ultimate disposal of any wastes.	Toro would implement management measures to comply with legislative and regulatory requirements for transport of uranium while stewardship of the product was its responsibility. Toro has also taken an active role in the development and implementation of industry stewardship programs which seek to influence operations in other phases of the nuclear cycle currently undertaken outside Australia and beyond the scope of this assessment.	• Safe Management of Product Transport
Eco-efficiency		
Producers of goods and services should produce competitively priced goods and services that satisfy human needs and improve quality of life, while progressively reducing ecological degradation and resource intensity throughout the full life-cycle to a level consistent with the sustainability of biodiversity and ecological systems.	Toro would monitor and report on key environmental performance indicators of its operation, including its use of energy and water and the cumulative impacts arising from implementation of the Project.	• Integration of Land Disturbance and Rehabilitation • Limiting Mine Dewatering and Water Recycling • Energy Saving Initiatives

Principle	How Addressed	Further Actions and Activities of Toro
Waste Hierarchy		
Wastes should be managed in accordance with the following order of preference: 1. Avoidance; 2. Reuse; 3. Recycling; 4. Recovery of energy; 5. Treatment; 6. Containment; and 7. Disposal.	The Project design choices are aimed at: • Avoiding the use of hazardous reagents (no use of solvent washing); • Adopting low energy demand processes; • Recovering power generation off-gases for use in ore processing; • Minimising the requirement to dewater mine pits (use of groundwater barriers); and • Using low quality (higher salinity) water to the extent practicable.	• Avoiding above ground structures by depositing all tailings below the natural grade of the land in mine voids • Limiting mine dewatering and recycling for process water; recovering energy, gas and steam in processing circuit.
Integrated Environmental Management		
If approaches to managing impacts on one segment of the environment have potential impacts on another segment, the best overall environmental outcome should be sought at a local, landscape, catchment and/or regional level	The social and environmental impact assessments presented in the PER specifically consider impacts at multiple scales in both space and time.	• Biophysical Environmental Impact Assessments • Environmental Management Framework

Principle	How Addressed	Further Actions and Activities of Toro
Best Practice		
When designing policies, systems, procedures or technologies for environmental management, best practice measures available at the time should be applied.	Toro has used the information generated through the investigations and studies outlined in this PER to develop environmental management strategies and procedures which would be effective and practicable, having regard to, among other things, local conditions and circumstances as well as available best practices.	• Integrating land disturbance and rehabilitation with restoration to original landform after mining • No above ground TSF to avoid dust and significant change to landform • Minimising mine dewatering through in-pit barriers • Recycling water to process circuit; avoidance of drilling and blasting in mining • Cultural mapping of Project Area with Traditional Owners • Radiation protection and management with worker doses to be less than half of limit • Collaboration with regional partners to achieve social objectives
Accountability and Transparency		
• The aspirations of the people of Western Australia for environmental quality should drive environmental management. • Members of the public should therefore be given: - Access to reliable and relevant information in appropriate forms to facilitate a good understanding of environmental issues; and - Opportunities to participate in policy and program development. • Environmental decisions should be made in a transparent manner and made public.	Toro has supported informed public participation in the environmental impact assessment process. To this end, Toro continues to actively engage with communities and stakeholders, and to provide opportunities for them to be informed about the Project and more generally about the uranium mining industry and the environmental management issues associated with uranium mining.	• Community and Stakeholder Consultation • Ongoing Communications and Reporting

20.15 Implementation and Operation: Key Management Strategies

Through its baseline environmental and social studies, and community and stakeholder consultation, Toro has identified five key areas of management endeavour. They are:

- Integration of land disturbance and rehabilitation;
- Use and management of saline ground water;
- Radiation safety;
- Tailings management; and
- Collaboration with regional partners to achieve social objectives.

These five focus areas influence the most significant environmental and social outcomes of the Project. Their effective management would support public acceptability of the Project by ensuring that its impacts were minimised and its benefits maximised.

20.15.1 Integration of Land Disturbance and Rehabilitation

Implementation of the Extension to the Wiluna Uranium Project would disturb no more than 1581.8 ha of land (Millipede 537.9 ha; Lake Maitland 1043.9 ha, including haul road). Toro has sought to limit disturbance by confining the extent of infrastructure outside the areas to be mined to essentially a haul road linking the Lake Maitland mining area to the processing plant and a water borefield. Other disturbance for laydown areas, overburden and topsoil storage, sedimentation ponds, evaporation ponds and the like would be positioned within the ultimate mining footprint to avoid unnecessary clearing.

As well as limiting land disturbance, Toro would also undertake progressive rehabilitation of pit voids. Where operationally practicable, no major void would remain open for more than 12 months. Integration of land disturbance and rehabilitation would limit dust sources and, in turn, reduce the amount of water required for dust suppression.

Key Management Actions

- Confining disturbance (including for access roads) to already disturbed areas where practicable; all clearing to comply with Toro's vegetation clearance procedure;
- Progressive rehabilitation of mining voids at similar elevations and slopes to original topography;
- Reservation of top soil for rehabilitation; and
- No off-road driving unless in emergency.

Performance Measures

- Total land disturbed compared with prediction;
- Total land rehabilitated compared with prediction;
- Limiting period mining voids are open;
- Ambient and deposited dust (quantity and quality); and
- Annual public reporting on total areas disturbed and rehabilitated.

20.15.2 Use and Management of Saline Water

The total maximum water demand for the life of the Wiluna Uranium Project, including during mining at Millipede and Lake Maitland, is estimated to be up to 2.5 GL/a. Most of this would be required for the operation of the processing plant, not mining and other activities.

Because the water table is shallow, mining would disturb local groundwater aquifers. Pit dewatering is required to allow safe mining. Some of the water flowing into pit voids would be recycled to the processing circuit to limit the need to source water from elsewhere.

Groundwater drawdown would be controlled by installing cut-off walls or barriers around the pit perimeter to limit the need for dewatering. Controlling the use of water which is highly saline would reduce the risk of spreading salt or other soluble groundwater constituents in the local environment.

At Lake Maitland, aquifer reinjection is proposed to manage surplus water from mine dewatering.

Key Management Actions

- Recycle mine dewatering water to the process circuit;
- Install barriers in pit voids to limit dewatering; and
- At Lake Maitland, aquifer reinjection of surplus water from mine dewatering.

Performance Measures

- Actual water abstraction compared with plan;
- Groundwater drawdown compared with prediction; and
- Amount of mine dewatering recycled to processing circuit.

20.15.3 Radiation Safety

While uranium is mildly radioactive, potential hazards from its mining can be controlled through well-established design and management practices.

Radiation exposures to workers, contractors and members of the public as a result of implementation of the Proposal would be low and kept well within internationally-accepted limits through management measures detailed in Section 14.

As a result of these measures:

- Radiation doses to workers would be less than a quarter of the internationally-accepted human exposure limit; and
- Radiation doses to members of the public, including as a result of product transport, would be less than a tenth of the internationally accepted human exposure limit.

Key Management Strategies

- Adoption of the ALARA principle in management of radiation doses for design and execution and execution of the Proposal;
- Minimising dust from operations;
- Best practice control system for processing, product packing and transport;
- Appointment of Wiluna Project Radiation Safety Officer; and
- Monitoring, Emergency Response and Security plans.

Performance Measures

- Annual doses to workers;
- Environmental doses; and
- Zero safety incidents in processing, product packing and transport.

20.15.4 Tailings Management

Ore would be mined at the rate of approximately 1.3 Mtpa. Most of this would become tailings after the uranium was extracted in the processing plant. Many mines use above ground structures to store tailings which can give rise to dust and other issues as well as result in significant change to landforms. For the Extension to the Wiluna Uranium Project, Toro would deposit all tailings below the natural grade of the land in mine voids at Millipede. This would include tailings produced from the processing of ore from Lake Maitland. Once the tailings had dried sufficiently to operate machinery on them safely, they would be capped with waste rock material and rehabilitated to a form similar to the surrounding landform.

Key Management Strategies

- Construct perimeter wall in-pit void;
- Construct engineered in-pit clay liners;
- Tailings deposition from multiple points around void perimeter;
- Excess water returned to process plant or evaporation pond;
- Tailings from Lake Maitland ore also stored at Millipede because of proximity to process plant; and
- Effective tailings cap to control radiation emanation.

Performance Measures

- Minimising and monitoring of seepage;
- Controlling the rate of rise of tailings; and
- Radiation control through tailings cap.

20.15.5 Collaboration with Regional Partners to Achieve Social Objectives

While implementation of the Wiluna Uranium Project would herald a new industry in Western Australia, it would not be the largest employer in the region. Some existing mines in the region have larger workforces than Toro plans, while the proposed Yeelirrie Uranium Mine would have a production capacity and life of mine greater than that of the Wiluna Uranium Project, including its extension.

The development of further mines in the region does provide opportunity for collaboration by industry participants to maximise the benefits of their presence to residents in the region. This has already occurred through the activities of the WRPA, but could be enhanced in a number of ways that Toro would pursue including, as discussed in Section 19.6:

- Providing and sharing information about the environment of the region;
- Generating research into regional radiological impacts;
- Protecting Aboriginal cultural heritage;
- Aboriginal community development;
- Enhancing community infrastructure;
- Meeting workforce requirements; and
- Supporting local and regional businesses.

Key Management Measures

- Community and Stakeholder Consultation Program;
- Appointment of Community Relations Manager and an Aboriginal Liaison Officer based at Wiluna; and
- Mining agreements with Native Title Holders and Claimants.

Performance Measures

- Number of employees recruited locally and regionally;
- Community benefits provided by mining agreements; and
- Number of issues of concern lodged in Toro's register of contact with communities and stakeholders.

20.16 Specific Commitments

Table 20.3 lists some of the major commitments that Toro can make at this stage in planning the Wiluna Uranium Project, including its Extension. These commitments are recorded in the PER and will be confirmed in the management and monitoring plans forming part of the Project's overall environmental management framework.

The major commitments in Table 20.3 are in addition to legislative and regulatory compliance.

The management measures Toro has proposed to meet its commitments would be further refined or amended as a result of improved practices or technological advances as contemplated by its environmental management framework.

Table 20.3: Specific commitments

Issue	Commitment	Context
Public and Workforce Exposure to Radiation	Toro would comply with internationally-accepted radiation limits for workers and the public and would set a goal of maintaining doses at less than 50% of the internationally-accepted limit for workers. PER Section 14	Dose minimisation and dose limitation are the internationally-accepted approach to radiation management and safety. The approach is designed to protect the health of the workforce and the public.
Dust from Land Disturbance and Mining Operations	Toro would seek to minimise land disturbance and undertake progressive rehabilitation of disturbed areas to limit exposures to dust. PER Sections 6 and 16	Implementation of the Extension to the Wiluna Project would require disturbance of no more than 1581.8 ha (Millipede 537.9 ha; Lake Maitland 1043.9 ha) over a period of about 12 years.
Vegetation Clearing Affecting Fauna Habitat	Toro would undertake progressive clearance of vegetation to allow fauna time to disperse to other areas. Habitat corridors and/or linkages would be retained wherever possible so that fauna could move between remaining habitat patches. Progressive rehabilitation of disturbed areas would include direct return of top soil that had been pre-stripped and stockpiled. PER Sections 6, 9, 10 and 16	Implementation of the Extension to the Wiluna Project would require disturbance of no more than 1581.8 ha (Millipede 537.9 ha; Lake Maitland 1043.9 ha) over a period of about 12 years.
Waste Management	After completion of the first pit void at Millipede, mineralised wastes from the Millipede and Lake Maitland deposits would be placed below ground level. Disturbed areas would be recontoured to blend in with the surrounding landscape. The form, scale and vegetation types used in rehabilitation design would mimic the pre-mining landscape. PER Sections 6 and 16	Mining has the potential to significantly alter landforms, particularly through leaving waste rock on the surface.

Issue	Commitment	Context
Water Management	To minimise the amount of groundwater to be pumped to allow safe mining, water barriers would be constructed prior to mining. At Millipede, surplus water from pit dewatering would be directed initially to pit voids for use in ore processing or for other operational requirements, including dust suppression. At Lake Maitland, downstream aquifer reinjection would manage surplus water from pit dewatering. At both Millipede and Lake Maitland, bunding for surface water management would seek to maximise its use for operational requirements. It would be only under the circumstances of extreme flooding that water would need to be discharged from site. In such circumstances, there would be a high dilution within a short distance. Discharge would only occur if the water complied with criteria to ensure there was no adverse environmental impact. PER Sections 6, 13 and 16	Much of the uranium resource occurs at or below the water table and dewatering of the open pits would be required. Groundwater drawdown can have an effect on vegetation and subterranean fauna. Prolonged or intensive rainfall events are rare in the Wiluna area, but if they occurred, there would be sheet runoff into drainage lines in the Project area.
Transport of Product	Toro would transport all product by road to Adelaide for shipment from Port Adelaide or rail to Darwin for shipment from Darwin Port. Toro would only use the eastern bypass road for transport of product in the vicinity of Kalgoorlie, rather than transport product through the centre city, and would avoid any stopping in the jurisdiction of the City of Kalgoorlie-Boulder for fuelling or driver-change. PER Section 19	The Government of Western Australia has made a policy decision that uranium should not be transported through Western Australian ports surrounding residential areas. Product transport management arrangements within the jurisdiction of the City of Kalgoorlie-Boulder have been proposed after discussions with the City Council and wider consultation in Kalgoorlie.
Workforce Recruitment	In recruitment, Toro would have a preference for young couples and 'empty nesters' who may wish to live in Wiluna. While engaging a core group of managers and operators with experience in uranium mining and processing, it would also have a priority to train people living locally and regionally who may be interested in careers in the resources sector. PER Section 19	Current mining operations in the Wiluna region are based on fly-in/fly-out arrangements for their workforces. There is concern in Wiluna that this limits the potential benefits from mining to the town.
Protection of Aboriginal Cultural Heritage	Toro is implementing a Cultural Heritage Management Plan to protect the cultural heritage values of the region. Toro would also implement cross-cultural awareness training for all employees and contractors. PER Section 15	The Project has the potential to impact on Aboriginal cultural heritage values, including registered archaeological and ethnographic sites.

Issue	Commitment	Context
Involvement of and Benefits to Aboriginal people	Toro's mining agreements with Native Title Holders and Claimants would include commitments to: • Training, employment and business development; and • Ongoing consultation with Aboriginal people through the life of the Project. PER Section 19	A large proportion of the population of Wiluna and the wider region is Aboriginal. The Project offers the opportunity to build capacity and skills, as well as provide other benefits.
Community Consultation	Prior to the commencement of construction, Toro would appoint a Community Relations Manager who would have responsibility for local and regional community consultation and engagement during the life of the Project. Toro would also appoint an Aboriginal Liaison Officer with specific responsibility for implementing mining agreements and managing relationships with Aboriginal people and groups. Toro would provide the opportunity for annual site visits by: • Representatives of the Wiluna community, including Traditional Owners; and • Representatives of non-government organisations. Toro would publish an annual report on its operational, environmental and social performance and have such a report externally audited every three years. PER Sections 4 and 19	It is important that local and regional communities in particular are kept informed about the Project, as it develops to enable them to assess whether its impacts are being managed and its benefits provided.

21 OVERVIEW AND CONCLUSION

The Wiluna Uranium Project, including its extension, presents the opportunity to provide a new and alternative source of uranium to international markets. The local and regional economic benefits (business and employment opportunities, and royalties and other revenues to government) are important.

Toro has prepared this PER in consultation with the Western Australian EPA and the federal DoE and in accordance with the EP Act (WA) and the EPBC Act (Cwlth).

Based on the legislation, regulations, policies, standards, guidelines and other relevant matters which have guided the development of this Proposal together with Toro's very extensive baseline survey work and understanding of the Proposal, it is concluded that the design features, management controls and mitigation measures described within the PER would enable potential impacts to environmental, socio-economic, health or cultural aspects to be managed to acceptable levels, whilst realising the benefits of the Proposal referred to above.

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23 GLOSSARY

23.1 Acronyms and Abbreviations

Acronym	Definition
AAEC	Australian Atomic Energy Commission
ABS	Australian Bureau of Statistics
AHD	Australian Height Datum
AHIS	Aboriginal Heritage Inquiry System
ALARA	As Low As Reasonably Achievable
AMSA	Australian Maritime Safety Authority
ANZECC	Australian and New Zealand Environment Conservation Council
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
ASNO	Australian Safeguards and Non-Proliferation Office
BITRE	Bureau of Infrastructure, Transport and Regional Economics
BoM	Bureau of Meteorology
CDNTS	Central Desert Native Title Services
CHMP	Cultural Heritage Management Plan
CIA	Cummulative Impact Assessment
CSIRO	Commonwealth Scientific and Industrial Research Organisation
Cwlth	Commonwealth
DAA	Department of Aboriginal Affairs (WA)
DEC	Department of Environment and Conservation (WA)
DER	Department of Environment Regulation (WA)
DoE	Department of Environment (Commonwealth)
DoIS	Department of Industry and Science (Commonwealth)
DMP	Department of Mines and Petroleum (WA)
DoH	Department of Health (WA)
DoW	Department of Water (WA)
DPaW	Department of Parks and Wildlife (WA)
DP	Direct Precipitation
DRF	Declared Rare Flora
EIS	Environmental Impact Statement
EMCL	Environmental Media Concentration Limit
EP Act	*Environmental Protection Act 1986* (WA)
EPA	Environmental Protection Authority (WA)

Acronym	Definition
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
ERDM	Environmental Radon Decay Monitor
ERMP	Environmental Review and Management Program
ESCAVI	Executive Steering Committee for Australian Vegetation Information System
ESD	Environmental Scoping Document
FCA	Federal Court of Australia
FRE	Fire Regeneration *Eucalyptus*
GDE	Groundwater Dependent Ecosystem
IAEA	International Atomic Energy Agency
IAP2	International Association for Public Participation
IBRA	Interim Biogeographic Regionalisation for Australia
ICRP	International Commission on Radiological Protection
IFC	International Finance Corporation
JORC	Joint Ore Reserves Committee
LAI	Leaf Area Index
LGA	Local Government Area
LLRD	Long-lived Radioactive Dust
LoS	Level of Service
LSA	Local Study Area
Mega	Mega Uranium Limited, former owner of Lake Maitland Uranium Project
MNES	Matters of National Environmental Significance
MRWA	Main Roads Western Australia
MWG	Muntjiljtarra Wurrgumu Group
NAHS	Ngangganawili Aboriginal Health Service
NEPC	National Environment Protection Council
NEPM	National Environmental Protection Measure
NHMRC	National Health and Medical Research Council
NLWRA	National Land and Water Resources Audit
NOAEL	'No Observed Adverse Effects' Level
NORM	Naturally occurring radioactive material
NPT	Treaty on the Non-Proliferation of Nuclear Weapons 1968 or Non-Proliferation Treaty
NVIS	National Vegetation Information System
OEPA	Office of the Environmental Protection Authority
PEC	Priority Ecological Community
PER	Public Environmental Review

Acronym	Definition
pH	Degree of alkalinity/acidity
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
PNEDR	Predicted No-effect Dose Rate
Project	Wiluna Uranium Project
Proponent	Toro Energy Limited
Proposal	Extension to the Wiluna Uranium Project
RMP	Radiation Management Plan
RnDP	Radon Decay Products
ROM	Run-of-mine
RSA	Regional Study Area
RWMP	Radioactive Waste Management Plan
SIA	Socio-economic Impact Assessment
SRE	Short-range endemic
TAFE	Technical and Further Education
TEC	Threatened Ecological Community
TEOM	Tapered Element Oscillating Microbalance
TMP	Transport Management Plan
Toro	Toro Energy Limited
TSF	Tailings Storage Facility
UOC	Uranium oxide concentrate
WRPA	Wiluna Regional Partnership Agreement

Abbreviation	Description
2σ	Two sigma means 'two standard deviations'. The 'standard deviation' is a measure of the variability of a set of results. In a normally distributed population, 95% of the results lie within about 2 standard deviations of the mean value.
$\mu g/m^3$	Micrograms per cubic metre
µGy/h	Micro grays per hour
µm	Micron or micrometre, a unit of length equal to one millionth part of a metre
µS/cm	Microsiemens per centimetre, a measure of electrical conductivity of water due to contained salts
Bq	Becquerel, a unit of radioactivity
Bq/m^3	Becquerels per cubic metre. A volumetric measure of radioactivity.
CO_{2eq}	Carbon dioxide equivalent
dB(A)	Decibel (Audio)

Abbreviation	Description
g/m/a	Grams per metre per year
GL/a	Gigalitres per year. One gigalitre is equal to 1,000,000,000 litres, or one million cubic metres.
ha	Hectare
km	Kilometre
L/s	Litres per second
m	Metre
m^3	Cubic metres
mAHD	Metres of elevation references to the Australian Height Datum.
mg	Milligram. One thousandth of a gram.
mg/L	Milligram per litre, approximately equivalent to one part per million.
mm	Millimetre. One thousandth of a metre.
Mm^3	Million cubic metres
m/s	Metres per second.
mSv	Millisievert, a measure of radiation dose to tissue
Mtpa	Million tonnes per annum. Same as 'million tonnes per year'.
MW	Megawatt (1,000,000 watts)
oz/a	Ounces per annum, a measure of gold production
PM_{10}	Particulate matter having an equivalent aerodynamic diameter equal to or less than 10 micrometres (a micrometre is one millionth of a metre)
sq km	Square kilometre or km^2, a unit of area one kilometre long by one kilometre wide.
t/m^3	Tonnes per cubic metre, a measure of density
TDS	Total dissolved solids, a measure of salinity
tpa	Tonnes per annum

23.2 Glossary

Term	Definition
Acid	A substance with a pH less than 7.0
Alkali	A substance with a pH greater than 7.0 – also known as a base or basic material
Alluvial	Description of soil deposited by river or flooded water
Aquifer	A water-bearing bed of permeable rock, sand or gravel
Areal	The bounded part of the space on a surface
Arid	An area with an average annual rainfall of less than 250 mm

Term	Definition
Artifact	The term used by the Traditional Owners participating in the survey for any physical object constructed from trees, shrubs or part thereof. In the present context, artifacts include shields, spears, food-carriers and any number of other uses not specifically identified during the survey
Bardi	Tree or shrub under which witchetty grubs are found. The presence of witchetty grubs is determined by the presence of a 'track' along the soil terminating at the base of the tree or shrub
Basin	The area drained by a river or creek and its tributaries
Bulb	A perennating organ comprised of a modified underground stem, generally surrounded by modified leaves. Contains food reserves from which the shoot emerges. Bulbs enable the species to survive between growing seasons
Bush tucker	Food native to Australia and present before European colonisation
Becquerel (Bq)	The Standard International (SI) unit of measurement of radioactivity defined as one radioactive disintegration per second
Best practice	The leading management practices used to prevent or minimise health, safety, environmental, social, cultural or economic impacts
Biodiversity	The range of genetic, species and ecosystem diversity present in a given ecological community or system
Bioregion	An area of land or water that contains a geographically distinct grouping of natural communities
Biota	The sum of all living organisms of an ecosystem, or of a defined area or period
Blasting	Detonation of explosive charge in a mine to break up rock
Bore	A hole drilled into the ground to intersect an aquifer and from which water may be pumped
Bund	A wall constructed of earth, rock or concrete to prevent the inflow of stormwater to a mining or mineral processing operation or to act as a secondary containment to prevent the outflow of liquids from tanks or other storage vessels
Calcrete	A hardened layer in or on soil formed as a result of climatic fluctuations in arid and semi-arid regions
Carnotite	A bright yellow, radioactive mineral that is an important source of uranium, formed by alteration of primary uranium-vanadium and occurring chiefly in sandstone
Catchment	The entire land area from which water (e.g. rainfall) drains to a specific water course or water body
Cation	An ion possessing a positive electrical charge
Chenopod	A member of a family of plants, mainly shrubs of saline and semi-arid regions including blueblushes, saltbushes and samphires
Convertor	A facility to turn uranium oxide into gaseous uranium hexafluoride as the next step in producing enriched uranium uranium fuel for use in a nuclear power reactor.
Costean	A process of sinking small pits, then cutting from one pit to another across the direction of the vein
Cover sequence	The layers of solid sand rock overlying an ore body

Term	Definition
Crusher	That section of a processing plant that mechanically crushes the ore into smaller pieces
Cumulative effects	The combined build-up of effects of multiple impacts of separate actions
Decay product	The product of the spontaneous radioactive decay of a nuclide (a type of atom). A nuclide such as uranium-238 decays through a sequence of steps and has a number of successive decay products associated with it in a decay series
Decommissioning	A formal process of removing a mine or infrastructure from being operational
Deposition	Laying down of particulate materials (e.g. sediment in a lake or tailings solids in a tailings storage facility)
Desktop study	A study undertaken in the office rather than in the field
Dewater	The removal of water
Dose equivalent	A measure of the radiation dose to tissue where an attempt has been made to allow for different relative biological effects of different types of ionising radiation. Measured in Sieverts (Sv)
Dose (radiation)	The radiation energy absorbed in a unit mass of material
Drawdown	The fall of water-level in a natural reservoir such as an aquifer due to pumping or artesian flow
Ecology	The science dealing with the relationships between organisms and their environments
Ecosystem	The biotic (living) and a iotic (non-living) environment within a specified location in space and time
Ecotoxicology	The branch of toxicology concerned with the study of toxic effects caused by natural or synthetic pollutants to the constituents of ecosystems, animal (including human), plant and microbial, in an integral context
Emerson Class	The Emerson aggregate test is a physical test to assess the susceptibility of soil aggregates to slaking or dispersion when exposed to water. The test is not generally applicable to sands, gravels or rock flour. Emerson class values range from 1 (very dispersive) to 6 (non-dispersive, very stable).
Emission	A discharge of a substance, such as dust into the environment
Endemic	A species not naturally found elsewhere
Environmental Management System	A set of policies, procedures and practice detailing the approach required to protect environmental values at a given location
Ephemeral	Something that is not permanent such as a stream that flows only seasonally or after rainfall, or a lake that periodically dries out, or a plant that is present seasonally
Ephemeral Drainage Line	A drainage line in which the presence of water is generally restricted to after episodes of rainfall. The duration of water within the drainage line is typically very short
Eremaean Botanical Province	A broad floristic region within the centre of Western Australia, extending from the coast to the desert. The region is characterised by sporadic rainfall and contains the arid interior
Ethnography	The scientific description of societies and cultures of human kind

Term	Definition
Evapotranspiration	The sum of evaporation and plant transpiration from the Earth's land surface to atmosphere. Evaporation accounts for the movement of water to the air from sources such as soil and water bodies. Transpiration accounts for the movement of water within a plant the subsequent loss of water as vapour through the leaves
Extant	A family, class or species that still exists.
Extinct	A family, class or species that has died out.
Fauna	The animal life of a region or geological period
Feral	An organism that has escaped from domestication and returned to its wild state
Flora	The plants of a particular region, geological period or environment
Footprint	The area taken up by a development
Gamma radiation	A form of electromagnetic radiation similar to light or x-rays, distinguished by its high energy and penetrating power
Grade	The concentration of metal either in an individual rock sample or averaged over a specified volume of rock; uranium grade is usually given in per cent
Greenhouse gases	The six gases listed in the Kyoto Protocol, capable of trapping heat within the Earth's atmosphere: carbon dioxide, methane, nitrous oxide, hydroflurocarbons, perflurocarbons, sulphur hexafluoride
Groundwater	Water that exists beneath the Earth's surface in the pores and spaces of rock and soil
Groundwater mound	The local rise of a water table above its natural level resulting from a localised source such as infiltration from the tailings storage facility
Habitat	A specific place or natural conditions in which a plant or animal lives
Haul trucks	Heavy vehicles used to transport ore or waste rock
Hazard	A source of potential harm, or a situation with a potential to cause loss or adverse impact
Heavy metals	Any metal that has a specific gravity greater than about 5. Generally used to describe the following metals: arsenic, iron, manganese, silver, mercury, chromium, lead, zinc, copper, nickel, selenium and cadmium
Host rock	Rock or geological formation that contains or surrounds an ore body
Hydrogeology	The study of groundwater with particular reference to geology and including its origin, occurrence, movement and quality
Hydrology	The study of water, particularly its movement in streams, rivers or underground
Hydrophobicity	Water repellence
Indicator	Any physical, chemical, biological, social or economic characteristic of the environment used to assess its environmental condition
Indigenous	Belonging to or found naturally in a particular environment and referring to people of Aboriginal and Torres Strait Islander origin, including those who for census purposes, identify themselves as being of Indigenous origin
Infrastructure	A set of interconnected structural elements that provide the framework supporting an entire structure including utilities and transport. It may refer to buildings, water pipelines, gas pipelines, transmission lines, roads, railways, airports
In situ	In the natural or original position or place

Term	Definition
Ionising radiation	Radiation which interacts with matter to add or remove electrons from the atoms of the material absorbing it, producing electrically charged (positive or negative) particles called ions
Isotope	Forms of a chemical element having the same number of protons, but a different number of neutrons. All isotopes of the same element have the same chemical properties and therefore cannot be separated by chemical means
Leach	Dissolution and removal of a soluble substance from a substrate
Leaching	A chemical process for the extraction of minerals from ore
Liquor	An aqueous solution, emulsion or suspension
Martu people	Aboriginal people who traditionally lived around the southern end of the Canning Stock Route in Western Australia, running through the Great Sandy and Little Sandy deserts between the towns of Halls Creek and Wiluna
Median age	The age that divides a population group into exactly two halves
Median income	For census purposes, median income is the estimated midpoint of the distribution of individual income data are collected in ranges for a census, a uniform distribution of responses within each range is assumed, to calculate the median value
Mesa	An elevated area of land with a flat top and steep sides
Mine rock	Overburden and mineralised rock that is uneconomic to process
Mine water	All water used in mining and processing
Mineral resource	A concentration or occurrence of material of intrinsic economic interest in or on the Earth's crust in such form, quality and quantity that there are reasonable prospects for eventual economic extraction
Mineralisation	The occurrence of metal or minerals within a rock sequence that may potentially constitute ore
Mineralogy	The scientific study of minerals
Mitigation measure	Action taken to minimise or lessen the impact of an activity on the environment or surrounding communities
Model	A simplified representation (usually mathematical) of a complex system or event
Modelling	The process of creating and using a model
Murchison	One of the 51 bioregions of the Interim Biogeographic Regionalisation of Australia (IBRA)
Native Title	The recognition in Australian law of the continued ownership of land by Aboriginal and Torres Strait Islander people
Northern Botanical Province	The sub-tropical and tropical north of Western Australia
Ore	A mineral or mixture of minerals containing a metal in sufficient amounts for its extraction to be profitable
Ore body	A solid mass of ore that is geologically distinct from the rock that surrounds it and can be mined profitably
Ore reserve	The part of a mineral resource which can be mined and forms valuable or useful minerals that can be recovered economically

Term	Definition
Overburden	Material that is located above a deposit of ore, soil or rock which must be removed for the ore to be mined
Palaeochannel	Unconsolidated sediments or semi-consolidated sedimentary rocks deposited in an ancient, currently inactive river and stream channel system
Particulate	Tiny particles of solid or liquid suspended in a gas. They range in size from less than 10 nanometres to more than 100 micrometres in diameter
Permeability	The capacity of a material to allow fluid(s) to pass through it
pH	A measure of the degree of acidity or alkalinity of a solution expressed numerically on a scale of 1 to 14, on which 1 is most acidic, 7 is neutral and 15 is most basic (alkaline)
Playa	A salt lake, typically large in a closed basin with extensive internal drainage, common in arid and semi-arid areas of Australia
Potable water	Water suitable for human consumption
Precipitation	The process of changing from a dissolved compound into a solid, insoluble compound
Pregnant liquor	An acidic solution containing valuable mineral components (i.e. uranium) extracted by leaching
Processing plant	Where metals are extracted from a mined ore
Progeny	The isotopes or elements formed by the nuclei of radionuclides during radioactive decay. Also known as ‘decay chain products’ and ‘daughter products’
Putrescible	Predisposed to decompose, decay or spoil, especially by bacterial action
Radionuclide	Any nuclide (isotope of an element) which is unstable and undergoes natural radioactive decay
Radon	The heaviest of the inert gases. The predominant isotope, radon-222, is the decay product of radium-226. It has a half life of 3.8 days and decays to polonium-218 by the emission of an alpha particle
Reagents	The chemicals and solutions used in extracting metals from ore
Receptor	A designated place at which an impact may occur
Recharge	The addition of water to an aquifer, directly from the surface, indirectly from the unsaturated zone, or by discharge from overlaying or underlying aquifer systems
Rehabilitation	The process of restoring land to its previous natural state or to another use after mining has been completed
Reserve (mineral)	The economically mineable part of a measured or indicated mineral resource
Resource	A concentration or occurrence of natural, solid, inorganic or fossilised organic material in or on the earth’s crust in such form, quantity and quality that its extraction is likely to have economic benefit
Samphire	Common term for *Tecticornia* spp.vegetation. Samphire vegetation is typically located over saline groundwater on clays
Sedimentation	The deposition of particles such as soil or organic material from a state of suspension in water or air
Seepage	The flow of a fluid through soil pores
Sensitive receptor	A non-occupational area or group of people likely to be affected by potential impacts

Term	Definition
Sievert (Sv)	The SI derived unit of dose equivalent which attempts to reflect the biological effects of radiation as opposed to the physical aspects which are characterised by the absorbed dose and the quality factor and any modifying factor. It allows a comparison of the relatively greater biological damage caused by some particulates and fast neutrons. For most beta and gamma radiation, one sievert is equal to an absorbed dose of one joule per kilogram of biological matter
Southwest Botanical Province	A broad floristic region located in the South West of Western Australia. The region generally has predictable rainfall, with the majority failing during the winter months. Peak time for flowering is spring. This is the most floristically biodiverse section of Western Australia
Stygofauna	Fauna that live within groundwater systems, such as caves and aquifers
Sustainable development	Development that meets the needs of the present without compromising the ability of future generations to meet their own needs
Tailings	Crushed or finely ground mine rock suspended in water from which valuable minerals or metals have been extracted
Tailings storage facility	A retaining structure for tailings where the solids settle out and the tailings liquor is reclaimed for reuse or sent to evaporation ponds
Taxa	A name designating an organism or group of organisms
Tecticornia	A genus of succulent, salt tolerant plant largely endemic to Australia
Terrestrial	Pertaining to land
Throughput	Quantity of ore moving through an ore processing plant
Topography	The study of the Earth's surface features, concerned with local detail including relief and vegetative and human made features
Toxic	Poisonous to a specific organism
Toxicity	Effect of any substance that produces a harmful acute or chronic effect on living organisms
Transect	A line across a study area along which observations are made and changes can be observed
Transmissivity	The rate at which groundwater is transmitted through rock of a specific dimension and at specified hydraulic gradient
Troglofauna	Subterranean animals that exist only in caves and cavities, adapted to life in permanent darkness
Uranium (decay) series	A series of radionuclides produced in the decay of radioactive uranium to stable lead, The most important steps in the series are uranium-238 to uranium-234 to thorium-230 to radium-226 to radon-222 (and its decay products) to lead-210 and finally to lead-206, the stable non-radioactive end product
Water balance	The sum of the inputs and outputs and changes in storage levels of water in a given locality
Water table	The surface of the groundwater, below which soil and rock are saturated
Wattle	Common name for *Acacia* species
Woomera	Device made from wood used to throw spears

Note on Uranium Product Terminology

Uranium is priced and sold as 'U_3O_8' equivalent. Depending upon the processing method, the actual chemical composition of any uranium product may contain more water or oxygen than the compound U_3O_8. Accordingly the term 'uranium oxide concentrate' (UOC) is used to cover a variety of uranium oxides. The product that would be produced by the Wiluna Uranium Project, including its extension, has the chemical formula $UO_4.2H_2O$. This product contains about 70% uranium (by weight), compared to 85% uranium in U_3O_8. In order to present information in a way that is consistent with usual industry practice, the production quantities described in this PER may be expressed as U_3O_8 equivalents. The planned production for the Proposal is 1200 tpa of $UO_4.2H_2O$, which is approximately equivalent to 1000 tpa of U_3O_8.