Conceptual Mine Closure Plan

PROJECT:	**YEELIRRIE URANIUM PROJECT**
COMPANY:	CAMECO AUSTRALIA
MINERAL FIELD NUMBER	53
DOCUMENT ID:	YRE-MCP-001
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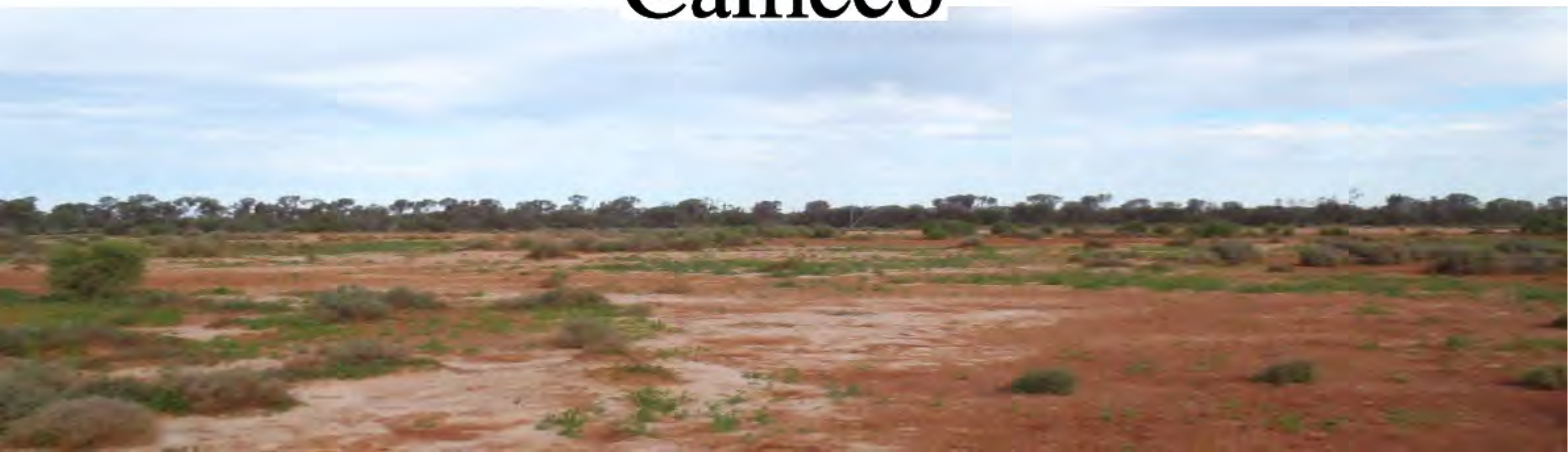
Cameco



Mine Closure Plan Checklist

Question No.	Mine Closure Plan checklist	Y/N or NA	Page No.	Comments
1	Has the MCP Checklist been endorsed by a senior representative within the tenement holder/operating company? (See bottom of Checklist)	Y	iii	
Public Availability				
2	Are you aware that from 2015 all MCPs will be made publicly available?	Y		
3	Is there any information in this MCP that should not be publicly available?	N		
4	If "Yes" to Q3, has confidential information been submitted in a separate document/ section?	NA		
Cover Page, Table of Contents				
5	Does the cover page include: • Project Title • Company Name • Contact Details (including telephone numbers and email addresses) • Document ID and version number • Date of submission (needs to match the date of this checklist	Y	NA	
Scope and Purpose				
6	State why is the MCP submitted	Y	Section 1	
Project Summary				
7	Does the project summary include: • Land ownership details • Location of the project • Comprehensive site plan(s) • Background information on the history and status of the project	Y	Section 2	Figure 2.1 and 2.2
Legal Obligations and Commitments				
8	Has a consolidated summary or register of closure obligations and commitments been included?	Y	Section 3	
Stakeholder Consultation				
9	Have all stakeholders involved in closure been identified?	Y	Section 4.1	
10	Has a summary or register of stakeholder consultation been provided, with details as to who has been	N		Attachment to PER

Question No.	Mine Closure Plan checklist	Y/N or NA	Page No.	Comments
	consulted and the outcomes?			
11	Does the MCP include a stakeholder consultation strategy to be implemented in the future?	Y	Section 4	
Post Mining Land Use(s) and Closure Objectives				
12	Does the MCP include agreed post-mining land use(s), closure objectives and conceptual landform design diagram?	Y	Section 5.3	Figure 9.1
13	Does the MCP identify all potential (or pre-existing) environmental legacies, which may restrict the post-mining land use (including contaminated sites)?	N		No specific restrictions
14	Has any soil or groundwater contamination that occurred, or is suspected to have occurred, during the operation of the mine, been reported to DER as required under the Contaminated Sites Act 2003?	NA		
Development of Completion Criteria				
15	Does the MCP include an appropriate set of specific closure criteria and/or closure performance indicators?	Y	Section 6	
Collection and Analysis of Closure Data				
16	Does the MCP include baseline data (including pre-mining studies and environmental data)?	Y	Section 7	
17	Has materials characterisation been carried out consistent with applicable standards and guidelines (e.g. GARD Guide)?	Y	Section 7	
18	Does the MCP identify applicable closure learnings from benchmarking against other comparable mine sites?	Y	Section 7.13	Rehabilitation trial
19	Does the MCP identify all key issues impacting mine closure objectives and outcomes (including potential contamination impacts)?	Y	Section 7	
20	Does the MCP include information relevant to mine closure been collected for each domain or feature?	Y	Section 7	
Identification and Management of Closure Issues				
21	Has a gap analysis been conducted to determine if further information is required in relation to closure of each domain or feature?	Y	Section 8.5	
22	Does the MCP include the process, methodology, and has the rationale been provided to justify identification and management of the issues?	Y	Section 8	
Closure Implementation				
23	Does the MCP include a summary of closure	Y	Section 9	

Question No.	Mine Closure Plan checklist	Y/N or NA	Page No.	Comments
	implementation strategies and activities for the proposed operations or for the whole site?			
24	Does the MCP include a closure work program for each domain or feature?	Y	Section 9	
25	Does the MCP contain site layout plans to clearly show each type of disturbance?	Y	Section 2	
26	Does the MCP contain a schedule of research and trial activities?	Y	Section 7	Specific dates not provided
27	Does the MCP contain a schedule of progressive rehabilitation activities?	Y	Section 9	Specific dates not provided
28	Does the MCP include details of how unexpected closure, and care and maintenance, will be handled?	Y	Section 9.4	
29	Does the MCP contain a schedule of decommissioning activities?	Y	Section 9	High level only
30	Does the MCP contain a schedule of closure performance monitoring and maintenance activities?	Y	Section 10.1	Specific dates not provided
Closure Monitoring and Maintenance				
31	Does the MCP contain a framework, including methodology, quality control and remedial strategy, for closure performance monitoring, including post-closure monitoring and maintenance?	Y	Section 10	High level only
Financial Provisioning for Closure				
32	Does the MCP include costing methodology, assumptions and financial provision to resource closure implementation and monitoring?	Y	Section 11	Provision not included
33	Does the MCP include a process for regular review of the financial provision?	Y	Section 11	
Management of Information and Data Management				
34	Does the MCP contain a description of management strategies, including systems and processes, for the retention of mine records?	Y	Section 12	

CORPORATE ENDORSEMENT

“I hereby certify that to the best of my knowledge, the information within this Mine Closure Plan and checklist is true and correct, and addresses all the requirements of the Guidelines for the Preparation of a Mine Closure Plan.”

Name: Brian Reilly
Signed:
Position: Managing Director
Date: 15/09/2015

(NB: The corporate endorsement must be given by tenement holder(s) or a senior representative authorised by the tenement holder(s), such as a Registered Manager or Company Director).

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LIST OF ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation	Description
AER	Annual Environmental Report
ABA	Acid Base Accounting
AHD	Australian Height Datum
ANC	Acid Neutralising Capacity
ANCOLD	Australian National Committee on Large Dams
ANZECC	Australian And New Zealand Environment Conservation Council
ANZMEC	Australian And New Zealand Mineral And Energy Council
ARD	Acid Rock Drainage
bcm	Bank Cubic Metres
BOM	Bureau Of Meteorology
CEC	Cation Exchange Capacity
CEO	Chief Executive Officer
cm	Centimetres
DAFWA	Department of Agriculture and Food Western Australia
DEC	Department of Environment And Conservation (Western Australia)
DFES	Department of Fire and Emergency Services (formerly the Fire and Emergency Services Authority) (Western Australia)
DME	Department of Minerals and Energy (Western Australia)
DMP	Department of Mines And Petroleum (Western Australia)
DoA	Department of Agriculture (Western Australia)
DoIR	Department of Industry And Resources (Western Australia)
DoW	Department of Water (Western Australia)
DRF	Declared Rare Flora
EC	Electrical Conductivity
EFA	Ecological Function Analysis
EMP	Environmental Management Plan
EMS	Environmental Management System
EOM	End Of Mine
EP Act	Environmental Protection Act
EPA	Environmental Protection Authority (Western Australia)
EPBC Act	Environment Protection And Biodiversity Protection Act
Eqn	Equation
ESP	Exchangeable Sodium Percentage
EWD	Early Warning Detection
FD	Functional Diversity
FESA	Fire And Emergency Safety Authority
FOS	Factor Of Safety
GDE	Groundwater Dependent Ecosystem

Acronym/Abbreviation	Description
GST	Goods And Services Tax
GWL	Groundwater Level
ha	Hectare
HCWA	Heritage Council of Western Australia
HDPE	High-Density Polyethylene
ICMM	International Council on Mining and Metals
hr	Hour
kg	Kilogram
km	Kilometre
km2	Square Kilometres
kVa	Kilovolt-Ampere
L	Litres
LiDAR	Light Detection And Ranging
LOM	Life Of Mine
LV	Light Vehicle
m	Metre
M	Million
m2	Square Metre
m3	Cubic Metre
max	Maximum
MCP	Mine Closure Plan
MD	Metalliferous Drainage
meq	Milliequivalent
mg	Milligram
min	Minimum
mm	Millimetre
mmol	Millimole
MP	Mining Proposal
mS	Millisiemen
Mtpa	Million Tonnes Per Annum
NAF	Non Acid-Forming
NAG	Net Acid Generation
NAPP	Net Acid Producing Potential
NATA	National Association of Testing Authorities
NOI	Notice Of Intent (now referred to as Mining Proposal)
°C	Degrees Celsius
OHS	Occupational Health And Safety
PAF	Potentially Acid-Forming
PAW	Plant Available Water
PEC	Priority Ecological Communities

Acronym/Abbreviation	Description
PER	Public Environmental Review
PFT	Plant Functional Types
PML	Post-Mine Landform
POF	Probability Of Failure
Qld EPA	Queensland Environmental Protection Agency
RL	Reduced Level
ROM	Run Of Mine
s	Second
S&RE	Soil and Rock Engineering
SER	Society for Ecological Restoration International Science & Policy Working Group
SEWPAC	Department Of Sustainability, Environment, Water, Population And Communities
SMU	Soil Management Unit
SRE	Short Range Endemic
STP	Sewerage Treatment Plant
SVMU	Soil Vegetation Management Unit
t	Tonnes
TDS	Total Dissolved Solids
TSF	Tailings Storage Facility
UCL	Unallocated Crown Land
USDA	United States Department of Agriculture
µm	Micron
VCL	Vacant Crown Land
WA	Western Australia
WMS	Watershed Modelling System Software
WRL	Waste Rock Landform
WWTP	Waste Water Treatment Plant
yr	Year

DEFINITIONS

Aspect – Critical elements of closure that need to be considered.

Care and Maintenance – Phase following temporary or unexpected cessation of mining operations where infrastructure remains intact and the site continues to be managed. All mining operations suspended, site being maintained and monitored.

Closure – A whole-of-mine-life process, which typically culminates in tenement relinquishment, including decommissioning and rehabilitation.

Closure Objective – Outcome based long term goals for closure, based on the post mining land use.

Completion – The goal of mine closure. A completed mine has reached a state where mining lease ownership can be relinquished and responsibility accepted by the next land user (DITR, 2006a).

Completion Criteria – Qualitative or quantitative standards of performance used to measure the success of meeting the closure objectives.

Decommissioning – A process that begins, near or at, the cessation of mineral production and ends with removal of all unwanted infrastructure and services.

Disturbed - Area where vegetation has been cleared and/or topsoil (surface cover) removed.

Disturbance Type - A feature created during mining or exploration activity, e.g. waste rock landforms, haul roads, access roads, ROM, plant site, tailings storage facility, borrow pits, drill pads, stockpiles, office blocks, accommodation village, etc.

Domain - A group of features (landforms or infrastructure) with similar rehabilitation and closure requirements.

Legal Obligations Register – A register of all legally binding conditions and commitments relevant to rehabilitation and closure at a given mine site.

Life of Mine (LoM) – Expected duration of mining and processing operations.

Post-mining land use – Term used to describe a land use that occurs after the cessation of mining operations.

Rehabilitation – The return of disturbed land to a stable, productive and/or self-sustaining condition, consistent with the post-mining land use.

Relinquishment – A state when agreed closure criteria have been met, government “sign-off” achieved, all obligations under the Mining Act removed and bonds retired, and responsibility accepted by the next land users or manager (DITR 2006a (DITR, 2006a).

Revegetation – Establishment of self-sustaining vegetation cover after earthworks have been completed, consistent with the post-mining land use.

1 SCOPE AND PURPOSE

The Yeelirrie Uranium Project Conceptual Mine Closure Plan (MCP) covers the closure-related aspects associated with the mining of the uranium oxide resource at Yeelirrie and the operation of the mine site, including mine pits and tailings storage facilities, and deals with the way in which the operations will be rehabilitated and closed in accordance with the DMP / EPA Guidelines for Preparing Mine Closure Plans (DMP/EPA, 2015).

Cameco recognises the importance of mine closure planning to the successful and environmentally sustainable operation of any mining operation, and that successful mine closure requires integrated planning at all stages of the operations from pre-feasibility through to mine development and operations. The purpose of an MCP is to provide a strategic planning and implementation framework for the closure of the Project by:

- Identifying those aspects relating to decommissioning and closure which may impact on the environment, health and safety, and may be of concern to regulatory agencies;
- Providing a basis for consultation with regulators and identified stakeholders regarding the post-mining land uses of the project area and agreed completion criteria;
- Developing management strategies to be implemented as part of the project’s design, construction and operation to minimise impacts and site closure requirements;
- Identifying closure costs to establish adequate financial provisions;

An MCP document is most effective at achieving successful mine closure if it is a ‘living’ document, which is reviewed and updated regularly in response to changes in site conditions, innovation in management processes, changes in technology and community expectations which may occur throughout the life of the operation. As the planning phase of the operation continues to develop, Cameco will be conducting a range of investigations and studies to further refine the knowledge of environmental risks and closure aspects of the operations and the results from these studies will be incorporated into the MCP. The proposed Life Cycle of the MCP is provided in Figure 1.1.

As the Yeelirrie Uranium Project is managed under a State Agreement Act and is therefore not subject to the Mining Act (1978), the Office of the Environmental Protection Authority (OEPA) will formally assess mine closure for the Project under Part IV of the Environmental Protection (EP) Act as stated in the Guidelines for Preparing Mine Closure Plans (DMP/EPA, 2015). As Rehabilitation and Closure was identified during the referral process as a Key Integrating Factor, the EPA has recommended the development of an MCP consistent with the DMP/EPA (2015) guidelines be prepared. This MCP will be submitted for review and approval by the OEPA every three (3) years following initial approval.

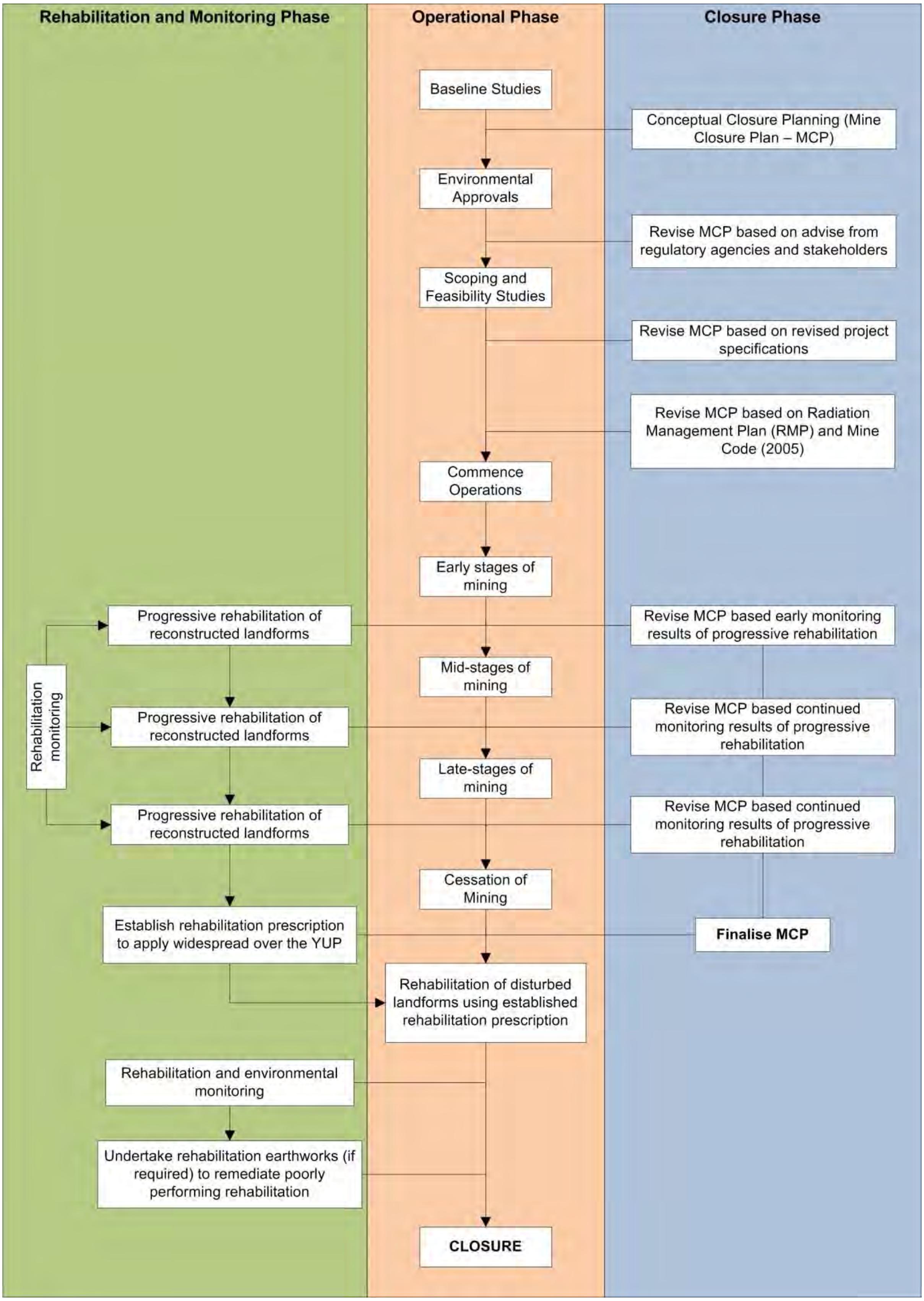


Figure 1.1: Life Cycle of the MCP throughout project development

2 PROJECT SUMMARY

2.1 LOCATION

The Yeelirrie Project is located on the Yeelirrie pastoral station in the Shire of Wiluna, approximately 70 km south of Wiluna, 420 km north of Kalgoorlie-Boulder, 110 km north-west of Leinster and 65 km west of Mount Keith. Land use in the area surrounding the proposed site is typical to the Western Australian Northern Goldfields area and consists predominantly of mining activities, pastoral stations and conservation reserves.

2.2 OWNERSHIP

The Yeelirrie Project is 100% owned by Cameco Australia Pty Ltd. Cameco Australia is a wholly owned subsidiary of Cameco Corporation, based in Saskatchewan Canada and recognised as a global leader in uranium mining, refining and nuclear fuel production.

2.3 TENURE

The Yeelirrie Project is subject to a State Agreement Act. The Yeelirrie State Agreement Act 1978, sets out the requirements for the development of the Project and a number of the Protect tenements were granted pursuant to the Act. The Project also includes a number of tenements granted under the Mining Act 1978.

A list of the active project tenements are included in Appendix A.

2.4 PROJECT HISTORY

Western Mining Corporation (WMC) discovered a uranium deposit at Yeelirrie in 1972 and in the decade that followed, undertook further exploration leading to trial mining and the installation of a pilot processing plant. Environmental studies were undertaken and a Draft Environmental Impact Statement (EIS) and an ERMP were submitted to the WA EPA and Australian Government in 1978. The project was approved by both the Australian and Western Australian governments in 1979.

Trial mining commenced and ore was extracted from three excavation pits. Between 1980 and 1982, it was sent to the Kalgoorlie Research Plant (pilot metallurgical plant) for processing test work. The project was placed on ‘monitored care and maintenance’ in 1984, after the newly elected Australian Labor Government implemented its three mines policy in 1983 and the Western Australian Government assumed an anti-uranium position in the same year. The three mines policy restricted Australia’s uranium production to three fully operational mines: Ranger and Nabarlek in the Northern Territory, and Olympic Dam in South Australia. ‘Monitored care and maintenance’ allowed for WMC to undertake, inspect and maintain rehabilitation of already disturbed areas.

The rehabilitation works were audited in 1996 and an Environmental Improvement Plan was developed by WMC to address the audit findings (WMC, 2004a). A monitoring and security program was then established to report results annually to the Department of Mines and Petroleum (DMP) (formerly the Department of Industry and Resources). From 2001 to 2004, a multi-phase closure plan was prepared and implemented with the objective of leaving the site in a safe and stable condition, and thus posing a low risk of any future impact to the environment or health and safety of any person who may visit the site. A post-closure environmental and radiation monitoring program was established and submitted to the Western Australian Government as an appendix to WMC's Annual Environmental Report (WMC, 2004a).

In the intervening years until 2007, WMC's focus had shifted away from Yeelirrie to favour an expansion of the Olympic Dam operation. In addition, both Australian and Western Australian government uranium policies were less favourable to uranium mine development, and the price of the resource had dipped in the early 2000s.

BHP Billiton Lonsdale Investments Pty Ltd (a subsidiary of BHP Billiton Limited) bought WMC in 2005, at which time the Western Australian Government had an administrative ban on uranium mining in the state and the Australian 'no new (uranium) mines' policy was still in place. These bans were lifted in 2007 and 2008 respectively.

Cameco acquired ownership of the Yeelirrie tenements from BHP in December 2012 and has since commissioned a mining pre-feasibility study to develop a practical solution to mining and in-pit tailings disposal.

2.5 OVERVIEW OF OPERATIONS

An overview of the operation is provided in Figure 2.1 and a comprehensive site plan is provided in Figure 2.2.

The proposed Yeelirrie development would produce up to approximately 7,500 tonnes per annum (tpa) of uranium peroxide ($UO_4.2H_2O$), more commonly referred to as uranium oxide concentrate (UOC), through the development and operation of an open pit mine and on-site metallurgical plant. This production tonnage would diminish toward the end of the life of the proposed development. The open pit mine would be about 9 km long, up to 1.5 km wide and about 10 m deep. Up to 14 million tonnes (Mt) of overburden and ore would be mined annually during the mining pre-production pre-strip phase, with an average extraction rate of around 8 Mtpa during the production phase. The mined material would be stockpiled near the open pit before being processed within the metallurgical plant, or backfilled into the pit, if it was not economic to process.

The metallurgical plant will use an alkali tank-leaching process, followed by direct precipitation, to produce UOC for containerized transport to Port Adelaide, from where it would be exported. All tailings generated during the metallurgical processing of the ore would be returned to the tailings storage facility (TSF) in the open pit.

The Yeelirrie Project has a construction, operation and decommissioning and closure timeline of 22 years. The mining schedule ultimately will depend on the timing and nature of government approvals and a final decision by the Cameco Board, which will be largely driven by economic factors. The current indicative timeline is shown in Figure 2.3.

The deposit will be mined in 15 blocks (MB#1 – MB#15). As the uranium bearing calcrete occurs just below the water table, the mining blocks will have to be dewatered prior to mining. The planned dewatering blocks (DB#1 – DB#8) have been designed to ensure that dewatering is one year ahead of the mining face.

Mining will commence two years prior to the start of milling. This ensures that sufficient ore is available for milling and that there is space for in-pit disposal of the tailings. Milling will continue two years after completion of the mining. Tailings from mining blocks MB#1 to MB#3 will be deposited in TSF Pond#1, consisting of five cells with an average size of 309,000 m^2. The tailings from mining blocks MB#4 to MB#15 will be placed in TSF Pond#2, consisting of five cells with an average size of 339,500 m^2. Pond#1 will be operated for seven years and Pond#2 for eight years. Deposition of tailings in the cells of Pond#1 and #2 will be on a six day rotation schedule. The annual rate of rise in each cell is 1.2 m.

Figure 2.1: Overview of Yeelirrie Uranium Project

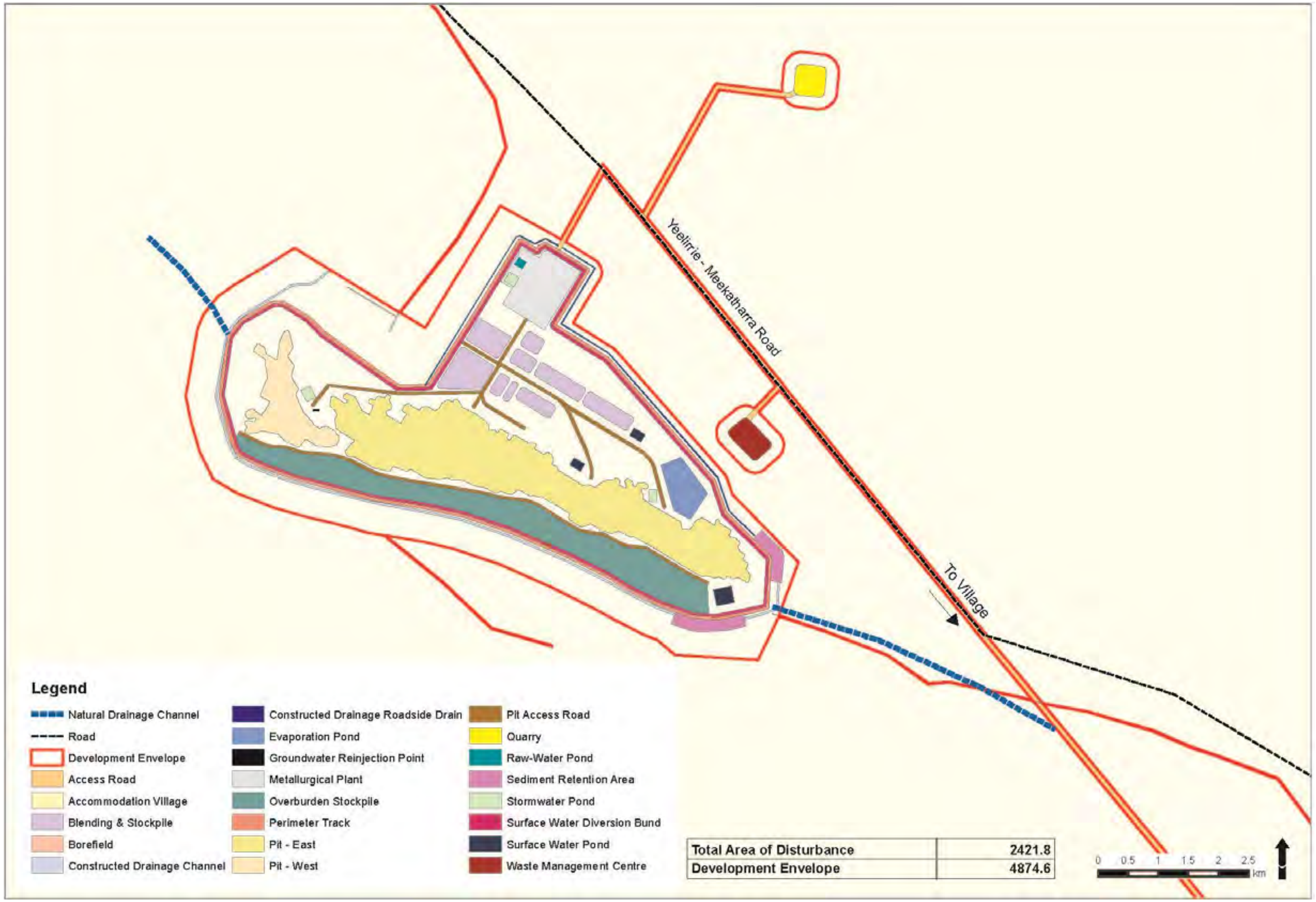
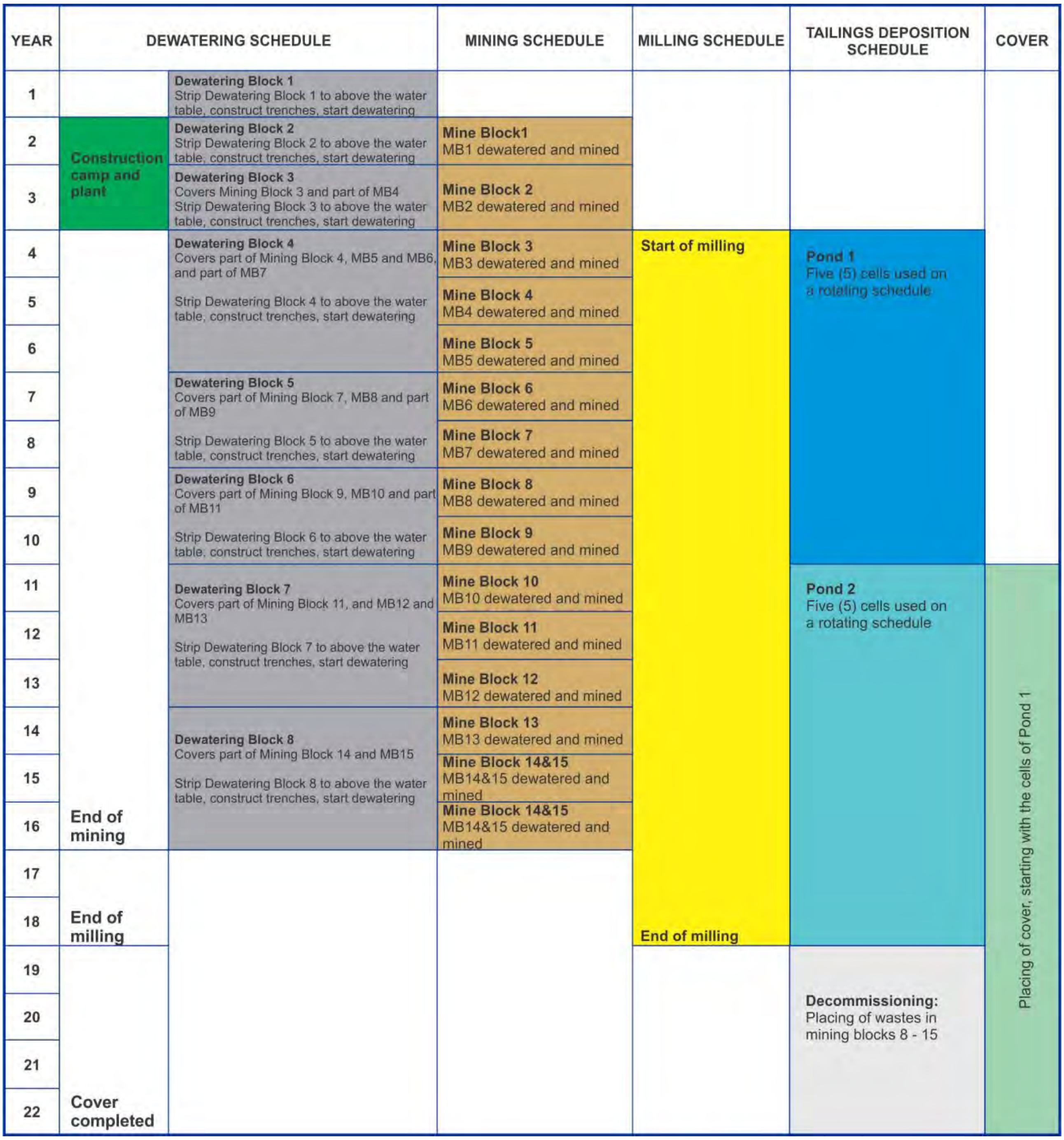


Figure 2.2: Yeelirrie Uranium Project Site Layout

Placement of a cover will start after filling of Pond#1 has been completed and tailings have consolidated and will be followed by covering Pond#2. Covering MB#8 to MB#14/15 will be done during the decommissioning of the site. The last cell to be filled and covered is MB#14/15.

Further details of the overall mine process are described in Section 6 of the PER document.



YEAR	DEWATERING SCHEDULE		MINING SCHEDULE	MILLING SCHEDULE	TAILINGS DEPOSITION SCHEDULE	COVER
1		**Dewatering Block 1** Strip Dewatering Block 1 to above the water table, construct trenches, start dewatering				
2	**Construction camp and plant**	**Dewatering Block 2** Strip Dewatering Block 2 to above the water table, construct trenches, start dewatering	**Mine Block1** MB1 dewatered and mined			
3		**Dewatering Block 3** Covers Mining Block 3 and part of MB4 Strip Dewatering Block 3 to above the water table, construct trenches, start dewatering	**Mine Block 2** MB2 dewatered and mined			
4		**Dewatering Block 4** Covers part of Mining Block 4, MB5 and MB6, and part of MB7 Strip Dewatering Block 4 to above the water table, construct trenches, start dewatering	**Mine Block 3** MB3 dewatered and mined	**Start of milling**	**Pond 1** Five (5) cells used on a rotating schedule	
5			**Mine Block 4** MB4 dewatered and mined			
6			**Mine Block 5** MB5 dewatered and mined			
7		**Dewatering Block 5** Covers part of Mining Block 7, MB8 and part of MB9 Strip Dewatering Block 5 to above the water table, construct trenches, start dewatering	**Mine Block 6** MB6 dewatered and mined			
8			**Mine Block 7** MB7 dewatered and mined			
9		**Dewatering Block 6** Covers part of Mining Block 9, MB10 and part of MB11 Strip Dewatering Block 6 to above the water table, construct trenches, start dewatering	**Mine Block 8** MB8 dewatered and mined			
10			**Mine Block 9** MB9 dewatered and mined			
11		**Dewatering Block 7** Covers part of Mining Block 11, and MB12 and MB13 Strip Dewatering Block 7 to above the water table, construct trenches, start dewatering	**Mine Block 10** MB10 dewatered and mined		**Pond 2** Five (5) cells used on a rotating schedule	Placing of cover, starting with the cells of Pond 1
12			**Mine Block 11** MB11 dewatered and mined			
13			**Mine Block 12** MB12 dewatered and mined			
14		**Dewatering Block 8** Covers part of Mining Block 14 and MB15 Strip Dewatering Block 8 to above the water table, construct trenches, start dewatering	**Mine Block 13** MB13 dewatered and mined			
15			**Mine Block 14&15** MB14&15 dewatered and mined			
16	**End of mining**		**Mine Block 14&15** MB14&15 dewatered and mined			
17						
18	**End of milling**			**End of milling**		
19					**Decommissioning:** Placing of wastes in mining blocks 8 - 15	
20						
21						
22	**Cover completed**					

Figure 2.3: Proposed mining schedule

2.6 CLOSURE DOMAINS

The major closure domains which have been identified for this project comprise of:

- Open Pit (to be backfilled)
- In-Pit Tailings Storage Facility (TSF) (within the confines of the Open Pit)
- Metallurgical plant
- Associated support infrastructure;
  - On-site quarry to provide raw construction materials
  - Pit dewatering system consisting of trenches, sump drains and pumps to lower the groundwater level within the pit to allow safe access to the ore body and to provide a primary process water supply
  - Evaporation ponds to contain and manage excess process water
  - Water supply well field and associated infrastructure to supplement the water obtained from pit dewatering
  - Surface water diversion system to exclude water from the mining area, the tailings and the stockpile areas
  - Electricity supply network powered by on-site diesel or gas fired generators
  - Various support buildings comprising workshops, offices and warehouses
  - Accommodation village catering for a peak on-site construction workforce of up to 1,200
  - Potable water and sewage treatment plant

2.6.1 BACKFILLED MINE PIT

The total open pit mining area is approximately 9 km long, with a variable width up to approximately 1.5 km wide, and about 10 m deep. The pit will be progressively dewatered and excavated in blocks, as outlined in Figure 2.3. Portions of the pit will be backfilled with waste material (“Backfilled Mine Pit” areas) and the remaining portion will be backfilled with process tailings (“In-Pit TSF” areas). As such, the mine pit will be completely backfilled at closure, and no open void will remain.

2.6.2 IN-PIT TSF

The majority of the open pit will be progressively backfilled with process tailings, and the land surface rehabilitated, so no open void will remain at site closure. Tailings deposition will occur in stages, into 10 tailings cells, with an average size of 324,000 m^3, as outlined in Figure 2.3.

2.6.3 METALLURGICAL PLANT

The metallurgical plant will use an alkali tank leaching process, followed by direct precipitation, to produce Uranium Oxide Concentrate (UOC) for containerised export from Port Adelaide. All tailings generated during the metallurgical processing of the ore would be returned to the In-pit TSF.

2.7 CLOSURE PLANNNING PROCESS

An MCP document is most effective at achieving successful mine closure if it is a ‘living’ document, which is reviewed and updated regularly in response to changes in site conditions, innovation in management processes, changes in technology and community expectations which may occur throughout the life of the operation. As the planning phase of the operation continues to develop, Cameco will be conducting a range of investigations and studies to further refine the knowledge of environmental risks and closure aspects of the operations and the results from these studies will be incorporated into the MCP. The proposed Life Cycle of the MCP is provided in Figure 1.1.

Given the early stage of this development, and the long expected LoM, this Conceptual Mine Closure Plan will only cover the Backfilled Mine Pit and In-Pit TSF closure domains in detail. Closure of the remaining processing and supporting infrastructure domains is discussed and more detail will be included in subsequent versions of the MCP. As required by the Guidelines for Preparing Mine Closure Plans (DMP/EPA, 2015), this MCP will be submitted for review and approval by the EPA every three (3) years as part of the continual mine closure planning process.

3 CLOSURE OBLIGATIONS AND COMMITMENTS

Closure obligations and commitments occur at two levels:

- General obligations and commitments, which are typically set by legislation and/or best-practice guidelines, and have been developed to promote environmental stewardship within the mining industry, and
- Site or activity-specific obligations and commitments, which are generally set by individual regulatory agencies to ensure environmental compliance and sound management practices.

The closure obligations and commitments which are pertinent to the Yeelirrie Project are provided below.

3.1 GENERIC CLOSURE OBLIGATIONS & COMMITMENTS

As the proposed development involves the mining and milling of uranium ore, it is deemed a ‘nuclear action’ by the Australian Government and automatically triggers a ‘controlled action’ requiring assessment under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). The Western Australian Environmental Protection Authority (EPA) determined that the proposed development should be assessed under Part IV of the Environmental Protection Act 1986.

3.1.1 ENVIRONMENT PROTECTION & BIODIVERSITY CONSERVATION ACT

The primary Australian Government legislation under which the proposed development will be assessed is the EPBC Act. This Act facilitates national environmental assessment and approvals, and aims to protect Australian biodiversity and integrate the management of important natural and cultural places. Under the provisions of the EPBC Act, actions that are likely to have a significant impact on any matter of national environmental significance (NES), or are nuclear actions, are subject to an assessment and approvals process.

3.1.2 ENVIRONMENTAL PROTECTION ACT

The EPA applies the following objective to the assessment of mine closure and rehabilitation:

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

The OEPA has developed policies to assist with achieving its objective. These include policies and guidance notes on the use of the precautionary principle, consideration of intergenerational equity, the conservation of biological diversity and ecological integrity, and waste minimisation.

The following regulatory position and guidance statements set the framework for the management of rehabilitation and mine closure:

- EPA and DMP (2015) Guidelines for Preparing Mine Closure Plans.
- EPA (2006) Guidance Statement No 6: Rehabilitation of Terrestrial Ecosystems.

The following are also position and guidance statements relevant to the management of rehabilitation and mine closure:

- EPA Guidance Statement Number 33: Environmental Guidance for Planning and Development (2008).
- EPA Position Statement Number 2: Environmental Protection of Native Vegetation in Western Australia (2000).

- EPA Position Statement Number 5: Environmental Protection and Ecological Sustainability of the Rangelands in Western Australia (2004a).
- EPA Position Statement Number 7: Principles of Environmental Protection (2004b).
- EPA Position Statement Number 8: Environmental Protection in Natural Resource Management (2004c).

3.1.3 REGULATORY APPROVALS

The primary approvals for the Yeelirrie Project are the approval by the Western Australian Minister for the Environment, granted following assessment under Part IV of the Environmental Protection Act 1986; and the approval granted by the Federal Minister of the Environment, under the provisions of the Environmental Protection and Biodiversity Conservation Act.

There are many other secondary approvals required before mining can commence as well as further licences and approvals that manage the transport of radioactive product from the Project. These are detailed in Section 3 of the PER.

3.1.4 STATE AGREEMENT

The proposed development is subject to the provisions of the Yeelirrie State Agreement, ratified by the Western Australian Parliament in 1978. This agreement facilitates the exploration, mining and treatment of certain uranium ores and associated minerals from mining areas that form the subject of the agreement, and allows for associated infrastructure to mine and process such ores.

These agreements specify the rights, obligations, terms and conditions for development of a project and establish a framework for ongoing relations and cooperation between the state and the project proponent.

State agreements have been used by successive WA governments to help foster major developments, including mineral, petroleum, wood processing and related downstream processing projects, together with associated infrastructure investments. Such projects require long-term certainty and extensive or complex land tenure, and are often located in relatively remote areas of WA that require significant infrastructure development.

3.1.5 MINING ACT 1978

The proposed development is also subject to the provisions of the Mining Act 1978 as a number of Project tenements have been granted under this Act.

3.1.6 BEST PRACTICE CLOSURE STANDARDS AND GUIDELINES

Cameco will apply the following best practice closure standards and guidelines to ensure environmentally sound development of the Yeelirrie Uranium Project:

- Strategic Framework for Mine Closure. This handbook was prepared by the Minerals Council of Australia, and the Australian and New Zealand Minerals and Energy Council (ANZMEC and MCA) in 2000. It outlines strategic framework concepts associated with stakeholder involvement, planning, financial provision, implementation, standards, and relinquishment. Examples of best practice are also included.
- Mine Closure and Completion. This document was prepared by the Department of Industry, Tourism and Resources (DITR) in October 2006 as part of an Australian Government initiative Leading Practice Sustainable Development Program for the Mining Industry. The publication addresses sustainable development and closure,

mine life phases, planning during the operational phase and mine completion and relinquishment, including case studies.

- Mine Rehabilitation. This handbook was published in October (2006a) within the Leading Practice Sustainable Development in Mining Series by the DITR. It outlines sustainable development and mine rehabilitation, planning, operations, and closure, and includes case studies addressing these aspects of mine rehabilitation.

3.2 CAMECO STANDARDS & GUIDELINES

Cameco Corporation has a Safety, Health, Environment and Quality Policy. Consistent with our vision, values and measures of success, Cameco Corporation (Cameco) recognizes safety and health of our workers and the public, protection of the environment, and quality of our processes as the highest corporate priorities during all stages of our activities, which include exploration, development, operations, decommissioning and reclamation. As such, we are striving to be a leading performer in all aspects of our business through a strong safety culture, environmental leadership, operational excellence and our commitment to the following principles:

- preventing injury, ill health, and pollution;
- complying with and moving beyond legal and other requirements;
- keeping risks at levels as low as reasonably achievable;
- ensuring quality of processes, products and services; and
- continually improving our overall performance.

In support of these principles, we:

- have a management system that provides a framework for these programs: quality management; safety and health management; radiation protection; environmental management; emergency preparedness and response; contractor management; and management system audit;
- set risk-informed objectives that will lead us to continually improve our overall performance in our safety and health management; radiation protection; and environmental management program areas;
- practice environmentally responsible mining practices, with a focus on our tailings and waste rock management and efforts to conserve biodiversity;
- conduct environmental assessments that consider environmental factors as well as social and cultural values throughout the project’s lifecycle, including ensuring facilities are designed for ultimate closure before proceeding with new operational projects;
- through Cameco’s policies, programs, and standards comply with and – where reasonable – move beyond:
    - applicable laws and regulations of the jurisdictions in which we operate; and
    - the intent of other leading industry practices to which we subscribe.
- systematically identify and mitigate to levels as low as reasonably achievable, those risks that have or may have a significant impact on safety, health, radiation protection, environment, and quality, taking social and economic factors into account;
- identify and reduce the potential for accidents and emergency situations including those involving the transport of our products, and implement emergency response plans to mitigate their impact;
- work with local communities, regulators and other stakeholders on the impact of our activities and our overall performance while responding to customers’ changing needs;
- systematically identify and address nonconformances;
- collaborate with all levels of government to enhance regulatory mechanisms;

- communicate this policy and provide a systematic approach when training employees and others performing tasks on behalf of Cameco on its implementation;
- monitor and measure the key characteristics of our operations;
- conduct regular audits to assess and ensure compliance with this policy;
- conduct research and develop new processes and products to solve technical barriers preventing the achievement of objectives and targets;
- encourage the participation of relevant employees in activities related to the implementation of this policy; and provide adequate and appropriate resources to implement this policy.

4 STAKEHOLDER CONSULTATION

Cameco has undertaken a comprehensive stakeholder and local community consultation process as part of the Project's Public Environmental Review. Foremost, this engagement strategy is aligned with Cameco's Five Pillars of Corporate Social Responsibility, which are endorsed on all of Cameco's operations. These pillars include:

- Workforce development: We are committed to train, educate and employ local people. In consultation with local communities, Cameco develops action plans to ensure effective education and training is available to allow local people to make the most of employment opportunities at our operations.
- Business development: We seek to build capacity in local stakeholder communities by assisting them in developing sustainable businesses to provide goods and services to our operations.
- Community investment: We invest in charitable projects that support community development, education and literacy, youth, and health and wellness initiatives.
- Community engagement: We build and sustain strong relationships with local community and government groups through open and direct communication. Cameco focuses on indigenous communication by listening to elders and youth and working to overcome cultural and language barriers.
- Government and regulatory relations: We seek positive, open relationships and partnerships with important stakeholders including governments and regulatory agencies.

4.1 STAKEHOLDER IDENTIFICATION

In developing the stakeholder consultation programme, Cameco was conscious that significant work had been completed by BHP Billiton. To help identify stakeholders and their issues, BHP Billiton established a Community Reference Group comprising local government and community representatives from Wiluna, Leonora, Menzies, Kalgoorlie-Boulder and Sandstone was established in June 2009. Stakeholder identification and analysis of issues included the feedback from this group in addition to a variety of other sources, including:

- outcomes of stakeholder meetings conducted from February 2009
- prevailing stakeholder perceptions identified by quantitative and qualitative research regarding attitudes towards uranium mining
- desktop research on a number of topics, including community profiles, industry bodies, regional organisations and service providers
- media analysis
- advice from industry groups, relevant associations and government bodies
- liaison with, and advice from, Central Desert Native Title Services (CDNTS), as the native title representative body
- discussions and research undertaken for other sections of the ERMP, including social, land use and economic investigations.

Following the acquisition of the Project by Cameco and supported by feedback from early communications with stakeholders about their needs and interests, the stakeholders were grouped into categories, given a rating regarding future needs and importance and consideration was given as to how best to engage each group.

In the current wave of consultation, priority was given to those groups who have a direct interest in the Project and those who are more likely to be interested in the content of the PER. Cameco recognises that there are other groups that haven't been provided priority at this time, and commits to ongoing consultation during and after the approval process.

In discussion with key stakeholders it became obvious that some stakeholders considered they had adequately consulted and informed, while others, in particular some Aboriginal community and family groups, were keen to hear more from Cameco. Based on this early feedback, Cameco has attempted to undertake a targeted consultation to serve three purposes; firstly, to provide some education and build awareness about uranium mining and related matters (such as radiation, dust, implications for bush tucker and transport, second, to inform stakeholders about the proposed development and to gain feedback on it, and third, to inform people about Cameco, including for example, our experience as one of the world's leading uranium miners and one of Canada's leading employers of Aboriginal people.

4.2 STAKEHOLDER ENGAGEMENT REGISTER

While the levels of stakeholder engagement are perhaps more intense during the preparation of Project approvals, it will continue through the life of an approval and for the life of the Project. For the purposes of the PER, Cameco has documented the stakeholder engagement that has been completed by the time of the lodging of the draft PER. The register is attached to the PER as Appendix C.

5 POST MINING LAND USE AND CLOSURE OBJECTIVES

5.1 PRE-MINING LAND USE

The land use in the wider area surrounding the Yeelirrie Project area primarily consists of a mix of pastoral stations, mining activities and conservation reserves. The Project area occurs within the Yeelirrie pastoral station which is owned and operated by Cameco. The Yeelirrie station is currently de-stocked and pastoral stations in the immediately surrounding regions are experiencing low profitability, chiefly from low commodity prices, and deteriorating pastoral conditions (e.g. climate change, land degradation, predation). Although conditions are difficult, pastoralism remains the dominant land use on the properties surrounding the Yeelirrie station.

The closest existing conservation reserve, the Wanjarri Nature Reserve, is located approximately 60 km south east of the Project area and there are several proposed reserves located south west of the Project area (PER Section 7). The closest of these, Kaulwiri, is located approximately 10 km south west. The Yeelirrie State Agreement Area overlaps the boundary of the proposed Kaluwiri reserve but no disturbance is planned within the reserve boundary.

5.2 HERITAGE

5.2.1 ABORIGINAL HERITAGE

There are four heritage sites registered with the WA Department of Indigenous Affairs (DIA) that are within the Project Area. None of these four registered sites are within areas proposed to be disturbed by the Project and therefore are not expected to be impacted. The implementation of large scale pastoral programs in the region has significantly affected traditional Aboriginal activities in the area, as it has done across large parts of the state. The Yeelirrie pastoral station currently continues to be accessed occasionally by Aboriginal people for hunting and collecting bush food and medicine.

Numerous other places have been recorded over the site that have been found to contain artefact material. Cameco will consult with Aboriginal people about these objects prior to the commencement of ground disturbing activities.

5.2.2 EUROPEAN HERITAGE

Project activities will not affect any listed or registered European heritage items.

5.3 POST MINE LAND USE

It is envisaged that the post mine land use will return to similar usage as pre-mine, with a mixture of land uses such as low intensity pastoral activities balanced against conservation of rare flora and fauna and the protection of indigenous values across the Yeelirrie station as a whole. In the short term, the areas of disturbance such as the mine pit areas and related infrastructure will be maintained as exclusion zones to allow revegetation to proceed. Once revegetation has become established as measured against developed closure criteria, the aim will be to remove the exclusion zone and allow full access. This approach will allow the land to rehabilitate to a stage where it will support the mixed land use activities reinstated once closure criteria and rehabilitation goals have been met.

Although the post-mine land use within the wider project area is expected to be returned to the mixed uses discussed above, the specific post-mine land use of the closure domains considered in this MCP are shown below in Table 5.1.

Table 5.1: Expected post-mine land use by closure domain

Closure Domain	Post Closure Land Aim	Specific Strategies to Facilitate Land Use
Backfilled Mine Void	Landform area will not inhibit low intensity grazing (pastoral) Area does not impact on surrounding environmental values or uses	Physical and geotechnical stability will not compromise sustainability of re-established ecosystem or surface water objectives
Tailings Storage Facilities (TSFs)	Landform area will not inhibit low intensity grazing (pastoral) Area does not impact on surrounding environmental values or uses	Physical and geotechnical stability will not compromise sustainability of re-established ecosystem or surface water objectives

5.4 CLOSURE OBJECTIVES AND GUIDING PRINCIPLES

As specified in the 2011 and 2014 MCP Guidelines, the overall objective of mine closure is to create a safe (to humans and non-human biota), stable (physically, geochemically and geotechnically), non-polluting environment across the mine project area that is capable of sustaining an agreed post-operational land use. To successfully achieve these goals, an integrated closure approach must be developed and maintained throughout the entire LOM with all groups within the company maintaining a clear idea of closure objectives.

Cameco's key closure objectives for the Yeelirrie Project include:

- Construction of a safe, stable, non-polluting post-mine environment that is capable of sustaining agreed post-operational land use, and does not impact on surrounding environmental values or uses;
- Ensure that no landscape features are introduced and that the mine voids are backfilled to close to original surface profiles;
- Control radiation levels at the surface of the rehabilitated landforms and across the project area to levels that are below accepted health guidelines;
- Return surface drainage systems to near natural flow direction and velocity, with runoff non-polluting to both surface and groundwater;
- Ensure the interests of all relevant stakeholders are considered during all stages of closure planning;
- Establish rehabilitation objectives and completion criteria, based on the findings of monitoring and research, that are appropriate to the agreed post-mine land use;
- Where practicable, progressively rehabilitate and revegetate disturbed areas in accordance with closure goals and;
- Revegetate disturbed areas with sustainable vegetation to meet agreed post-operational land use objectives and completion criteria.

6 COMPLETION CRITERIA

Completion criteria are measurable targets against which closure implementation, and subsequent performance, can be assessed. Identification of provisional criteria will commence during project approval stages, following stakeholder consultation and collection of baseline data. These provisional completion criteria will be continually reviewed and updated throughout the entire LOM (i.e. iterative feedback loop) as expectations of relevant stakeholders change overtime and in response to ongoing monitoring, research and trial rehabilitation information. This adaptive management approach allows changes in conditions throughout the project life to enhance not hinder efforts to develop relevant and effective completion criteria.

Completion criteria should be achievable, realistic and in alignment with stakeholder expectations and end land use objectives. They should not be developed in isolation (otherwise they will have no meaning), and should be intricately linked to:

- Broad closure objectives held for the project (i.e. construct a safe, stable, non-polluting and sustainable post closure environment);
- Stakeholder-agreed post-mine land use
- Monitoring approach (i.e. to guide what parameters are monitored and ensure no redundancy in monitoring approach)

The relationship between effective completion criteria and project specific conditions is depicted in Figure 6.1.

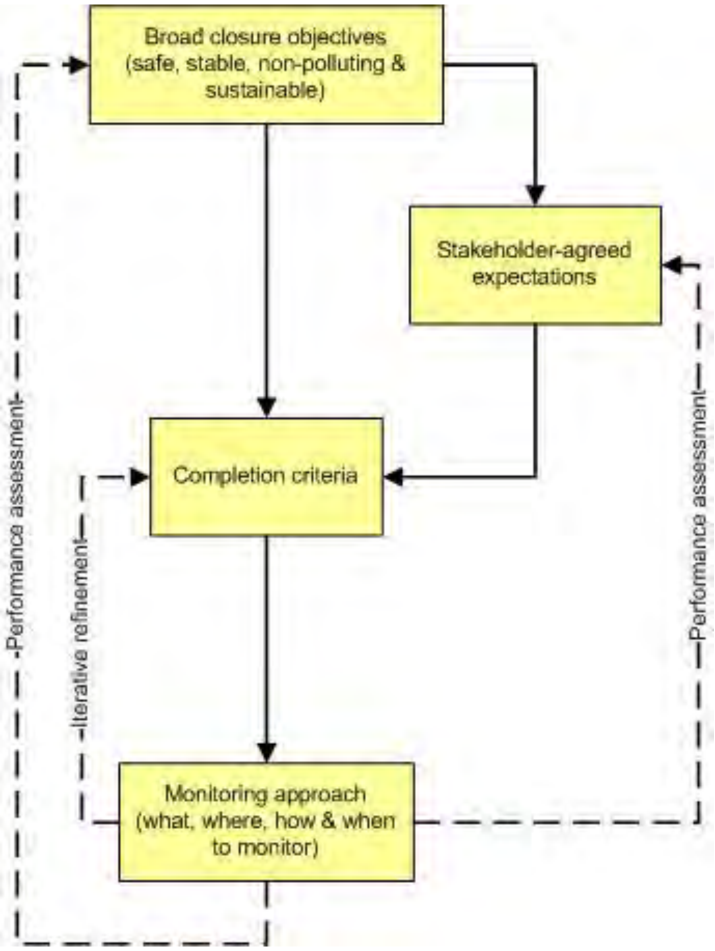


Figure 6.1: Relationship between completion criteria and other aspects of the closure process

6.1 BASIS FOR DEVELOPMENT

Provisional completion criteria for the Yeelirrie backfilled mine pits and TSF have been developed within the framework of the baseline data collected to date (Section 7) and the following documents:

- *Guidelines for Preparing Mine Closure Plans* (DMP, 2015);
- *Strategic Framework for Mine Closure* (ANZMEC & MCA, 2000);
- *Rehabilitation of Terrestrial Ecosystems* (EPA, 2006);
- Leading Practice Sustainable Development Program for the Mining Industry Handbooks for *Mine Closure and Completion* (DITR, 2006), *Mine Rehabilitation* (DITR,2006) and *Evaluation Performance: Monitoring and Auditing* (DITR, 2006)

The documents listed above provide the basis on which completion criteria development hinges. A review of the guiding principles within these documents yields the following basic standards which together define effective completion criteria.

Completion criteria should:

- Be specific enough to reflect unique environmental, social and economic circumstances;
- Be flexible enough to adapt to changing circumstances without compromising objectives;
- Include environmental indicators capable of being monitored and suitable for demonstrating that rehabilitation trends are heading in the right direction;
- Undergo periodic review in light of changed circumstances or improved knowledge resulting in modification if required;
- Be based on acquired and future targeted research which results in increasingly informed decisions

6.2 APPROACH

As discussed the development of completion criteria is an ongoing process throughout the life of mine with assessment of rehabilitation via monitoring against completion criteria carried out progressively. Periodic review of completion criteria ensures that modification of rehabilitation and monitoring procedures can be implemented where necessary.

6.3 DEVELOPMENT OF COMPLETION CRITERIA

The overall rehabilitation objectives for any given mine feature (e.g. backfilled mine pit, TSF) are primarily based on the closure objectives and agreed post mine land use. Cameco's rehabilitation objectives for the landforms which will be present at closure (i.e. backfilled mine pit and tailings storage facilities within the mine pit) is to ensure that they are safe, stable and non-polluting whilst being capable of sustaining the agreed post operational land use.

The purpose of completion criteria is both to provide a set of goals for rehabilitation efforts to work towards and provide a demonstration that a given domain or landform has achieved the rehabilitation objectives. This in turn delivers confidence to both regulators and post operational land users that these domains or landforms are capable of sustaining over the long term the agreed post mine land use, utilising normal management practices.

As discussed above, the development of completion criteria is most effective where it is undertaken as an iterative management approach. As such, the development of completion criteria will continue throughout the remaining planning stages of the project and through the operational period of the mine to allow integration of data from ongoing rehabilitation trials, research and monitoring.

The goals of this iterative development approach are to progressively refine baseline data accuracy, the effectiveness of monitoring activities and rehabilitation trial procedures to develop measurable metrics based on site specific data, providing confidence that completion criteria can fulfil the intended role within the mine closure planning framework.

As such the completion criteria presented at this stage are preliminary in scope, and are represent the first stages of the iterative management approach discussed above. The completion criteria developed for use at this stage in the Yeelirrie Project lifecycle are presented overleaf in Table 6.1. The criteria have been broken down into broad overall closure objectives and key environmental areas.

Table 6.1: Yeelirrie Domains (backfilled mine void and in-pit tailings storage facilities) Completion Criteria.

Subject	Objective	Criteria	Verification Tools	MCP Section
1.1 Safety	Site is safe for use under the agreed post mine land use(s)	Hazards which may endanger safety of humans or animals are identified and eliminated where possible. Residual safety hazards have been identified and appropriate management controls developed and implemented.	Relevant regulator guidelines have been met. Mine safety inspection audit.	Sections 8 and 10
1.2 Landform safety	Final landforms are safe	Landforms have been constructed as per management and operation guidelines for each domain	Rehabilitation audit monitoring confirms landforms constructed to design guidelines. Monitoring results display landform safety in relation to design criteria and relevant guidelines.	Sections 9 and 10
2.1 Landform Stability	Final landforms are stable	Landforms have been constructed as per management and operation guidelines for each domain	Rehabilitation monitoring confirms landforms constructed to design guidelines. Environmental reports available for review	Sections 9 and 10
2.2 Surface Stability	Constructed surface of landforms are stable and do not display significant erosion beyond that modelled	Surface of landforms have been constructed in accordance with guideline specifications for each domain	Rehabilitation monitoring confirms landform surfaces constructed to design guidelines. Rehabilitation monitoring results indicate surface is stable and within modelled limits	Sections 9 and 10
3.1 Sedimentation	Landform surfaces not prone to sediment transport beyond natural geomorphic processes	Surface of landforms have been constructed in accordance with guideline specifications for each domain	Rehabilitation monitoring confirms landform surfaces constructed to design guidelines. Rehabilitation monitoring results indicate surface is stable and within modelled limits	Sections 9 and 10

Subject	Objective	Criteria	Verification Tools	MCP Section
4.1 Sustainability	Rehabilitation is sustainable and suitable for the agreed post mine land use	Ecosystem function as defined by monitoring methods shows increasing trend and are comparable to baseline data	Rehabilitation monitoring shows ecosystem resilience and functioning are progressing along agreed trajectories towards sustainable post mine land use	Sections 8 and 10
4.2 Growth medium	Suitable growth medium is in place to facilitate rehabilitation and agreed post mine land use	Surface of landforms have been constructed using material identified as suitable for use in accordance with specific requirements for each domain	Rehabilitation monitoring confirms landform surfaces constructed to design guidelines Material movement scheduling records confirm landform surface have been constructed with suitable materials	Sections 9 and 10
4.3 Vegetation development	Vegetation is suited to the agreed post mine land use	Vegetation communities are suited to the agreed post mine land use and display resilience in ecosystem function	Rehabilitation monitoring shows ecosystem resilience and functioning are progressing along agreed trajectories towards sustainable post mine land use	Sections 8 and 10
4.4 Provenance	Vegetation is of local provenance	Vegetation communities are composed of local provenance species	Rehabilitation monitoring confirms local provenance species are forming vegetation communities	Sections 8 and 10
4.5 Weeds	Presence of weeds does not limit the sustainability of rehabilitation or its potential to sustain agreed post mine land use	Vegetation communities are suited to the agreed post mine land use and display resilience in ecosystem function	Rehabilitation monitoring shows ecosystem resilience and functioning are progressing along agreed trajectories towards sustainable post mine land use	Sections 8 and 10
5.1 Surface Hydrology	Mining related impacts on natural surface water flows is minimised	Landforms have been constructed as per management and operation guidelines for each domain	Rehabilitation monitoring confirms landforms constructed to design guidelines. Surface hydrology investigation/modelling confirms	Sections 9 and 10

Subject	Objective	Criteria	Verification Tools	MCP Section
			surface drainage has returned to near natural flow and velocity	
5.2 Groundwater Hydrology	Mining related impacts on groundwater quality and environmental receptors have been minimised	Monitoring results show groundwater quality within modelled constraints down gradient of mine closure domains	Groundwater monitoring of down gradient bores for contaminants of concern	Sections 8 and 10
6.1 Visual Amenity	Visual amenity of constructed landforms is comparable to original profiles	No introduced landscape features with each domains land-surface backfilled to close to original profiles	Rehabilitation monitoring confirms landforms constructed to management guidelines. Environmental reports available for review	Sections 9 and 10
6.2 Heritage	No unauthorised disturbance of heritage sites during rehabilitation and access to sites of significance preserved	Landforms have been constructed as per management and operation guidelines for each domain	Rehabilitation monitoring confirms landforms constructed to management guidelines. Stakeholder register has been completed Site heritage register has been maintained.	Sections 9 and 10

7 COLLECTION AND ANALYSIS OF CLOSURE DATA

The following section provides a summary of details on the physical and biological environment at the Yeelirrie Uranium Project, including:

- Local climatic conditions;
- Local environmental conditions – topography, geology and hydrogeology;
- Local and regional information on flora, fauna and subterranean fauna;
- Local water resources details – type, location, extent, hydrology, quality, quantity and environmental values (ecological and beneficial uses); and
- Soil and waste materials characterisation.

This information provides a basis for the development of completion criteria and performance indicators for closure monitoring.

The closure management of the mining operations is based on understanding the surrounding environment and the outcomes of monitoring and research trials.

7.1 INTERIM BIOGEOGRAPHIC REGIONALISATION OF AUSTRALIA

The Interim Biogeographic Regionalisation for Australia (IBRA) divides the continent into 85 bioregions and 405 subregions according to major geomorphic and biological features in each bioregion. The bioregions defined in the classification scheme are the largest units the Environmental Protection Authority (EPA) of Western Australia considers in assessing impacts on biodiversity.

The project area is located in the Murchison bioregion, and in the Eastern Murchison (MUR1) subregion — one of two subregions in the bioregion. The Murchison bioregion covers 281,000 square kilometres and is characterised by low hills and mesas separated by flat colluvium and alluvial plains. Vegetation is predominantly low mulga woodlands. The bioregion is one of the main pastoral (sheep and cattle) areas in Western Australia, although mining (gold, iron and nickel) is the greatest income generator of its economy. Major population centres are Leinster, Leonora, Meekatharra, Mount Magnet, Laverton, Cue and Wiluna.

7.2 CLIMATE

7.2.1 CLIMATE STATIONS IN THE YEELIRRIE CLIMATIC REGION

A detailed review of the long-term climatic conditions of the project area was conducted by Katestone Environmental Pty Ltd (Katestone, 2011). This review included:

- monitoring data from the Bureau of Meteorology (BoM)
- site-specific information from a local monitoring campaign undertaken in 1977 and 1981, as part of the Western Mining Corporation (WMC) assessment of the proposed Yeelirrie development area
- more recent and intensive data generated by a permanent weather station installed at the proposed mine site in September 2009.

The long-term BoM data was analysed from seven monitoring sites (Table 7.1). For the purpose of the ERMP, the region covered by these seven sites is referred to as the ‘Yeelirrie climatic region’.

Table 7.1: Existing monitoring stations operated by Bureau of Meteorology

Site	Type	Monitoring period analysed	Data frequency	Distance and direction to project site (approx)	Distance from site to WA coastline (approx)
Geraldton 008051	Synoptic	1993–2009	Hourly	540 km SW	50 km
Kalgoorlie– Boulder 012038	Synoptic	1994–2008	Hourly	430 km SSE	600 km
Meekatharra 007045	Synoptic	1993–2008	Hourly	150 km NW	470 km
Laverton 012305	Synoptic	1991– present	Hourly	300 km SE	760 km
Leinster 012300	Regional	1994–2009	Hourly	105 km SE	595 km
Wiluna 013012	Regional	2006–present	9 am and 3 pm	70 km NNE	630 km
Yeelirrie 012090	Local	2006–present	6 am, 9 am and 3 pm	20 km SE	600 km

7.2.2 SYNOPTIC OVERVIEW

The proposed Yeelirrie development is approximately 600 km inland. Average annual rainfall for the period 1928 to 2010 was 238 mm, varying between 43 and 507 mm. The average annual pan evaporation rate of 2,412 mm significantly exceeds the rainfall during the wettest year on record, contributing to the semi-arid nature of the region. Recorded temperatures range from a winter minimum of -5ºC to a summer maximum of 46ºC.

The weather of the Yeelirrie climatic region generally displays two modes: spring/summer, and autumn/winter, which are typified by a wet and a dry season respectively. Spring/summer conditions generally bring higher temperatures and lower mean sea level pressure as the climate is driven by the Australian monsoon; hence the higher rainfall and more variable weather in summer. During this period, the predominant winds are from the east to the south- west. The autumn/winter mode consists of lower temperatures, higher mean sea level pressure and a distinct lack of rainfall, as the driving mechanism of the regional and local climate shifts from an ocean-based to a land-based energy exchange. Winds are also predominantly from the east (see Chapter 13 for details). Finer detailed weather analysis for the project area identified four main types as the main contributors to the weather experienced in the region (see Table 6.2). Types 1 and 2 are dominant in summer and spring due to the generation of tropical lows associated with the Australian monsoon and the passage of fronts.

Types 2 and 3 take precedence in autumn and winter as the monsoon expires and the procession of low-pressure systems off the southern coast of Australia shifts further south. Type 3 is a result of the high-pressure system moving inland under Type 2 conditions. As the system approaches the centre of the continent, the daily heating and cooling of the large land mass causes the eastward movement of the system to slow and at times stall, becoming a stationary (blocking) high. Without the procession of fronts generated by tropical depressions (Type 1) to force eastward movement of the system, the high can remain stationary for several days, generating calm and settled weather. These conditions (Type 2 and 3) generally lead to the stratification of the nocturnal atmosphere, with warmer air held close to the ground under higher colder air (commonly referred to as inversion layers).

The frequency of Type 2 and 3 weather conditions found in the above analysis is consistent with findings presented by Steadman and Associates (1978), which estimated that nocturnal inversions are likely to occur on 44–63% of evenings in autumn and winter, with only a few instances likely during spring and summer.

Table 7.2: Weather types identified at the synoptic, regional and local scale

Weather type	Synoptic situation	General description
1	Monsoonal low off the north-west coast, trough moving inland, high-pressure	Hot, dry north-easterly winds
2	Ridge of high pressure pushing in behind front	Temperatures in the low 20s, 30–40% humidity, light easterlies tending south- westerly along the coast
3	High-pressure system over central Australia with associated fronts along the coast	Wide range of temperatures from below zero at night to above 30°C during the day, more moderate temperatures along the coast. Humidity stable around 50–70%, very light winds inland from the north-east to south-east with more moderate winds from the south-
4	Similar to Type 3 only high-pressure system is further south over the Great Australian Bight	Wide range of temperatures from below zero at night to above 30°C during the day, more moderate temperatures along the coast. High humidity 70–90%, very light winds inland from the south-east to north-west with more moderate winds from the south-east

7.2.3 RAINFALL INTENSITY-FREQUENCY-DURATION (IFD)

Design rainfall intensity and depth is presented in Table 7.3 and

Table 7.4 (respectively) for a range of storm duration and frequencies.

Table 7.3: Design rainfall Intensity-Frequency-Duration (IFD) information for the Yeelirrie Project Area

DURATION		Rainfall Intensity (mm/hr) for a given ARI					
		1 Year	5 years	10 years	20 years	50 years	100 years
10	Mins	32	59	70	84	103	118
30	Mins	18	34	40	48	59	67
1	Hr	12	23	27	32	39	45
6	Hrs	3.5	7.2	8.7	11	14	16
24	Hrs	1.3	2.8	3.5	4.4	5.6	6.6
72	Hrs	0.6	1.2	1.5	1.9	2.5	3.0

Table 7.4: Design rainfall Depth-Frequency-Duration (IFD) information for the Yeelirrie Project Area

DURATION		Rainfall Depth (mm) for a given ARI					
		1 Year	5 years	10 years	20 years	50 years	100 years
10	Mins	5.25	9.87	11.7	14.0	17.2	19.7
30	Mins	9.10	17.1	20.2	24.1	29.4	33.7
1	Hr	12.0	22.6	26.8	32.1	39.4	45.1
6	Hrs	21.1	42.9	52.3	64.2	81.0	94.2
24	Hrs	31.9	67.9	84.2	105	134	158
72	Hrs	40.3	88.6	111	139	179	212

7.3 OVERBURDEN CHARACTERISTICS

7.3.1 MATERIAL CHARACTERISATION STUDIES

Considerable background research has been conducted by Cameco via literature review into the geology of the wider project area, aimed at gaining an in-depth understanding of the processes which formed the current geological profile and the Yeelirrie resource. The results of this research are summarised below.

7.3.2 GEOLOGICAL SETTING

The Yeelirrie deposit is hosted within a broad gently undulating, Cenozoic aged, drainage channel which forms part of the Carey Palaeodrainage system. The system is formed from a series of ancient drainage valleys which were incised into the crystalline, Archaean aged basement rocks of the northern Yilgarn Craton during the Mesozoic. Cenozoic aged sedimentary deposits have since filled in these valley systems, typically occurring in defined layers with basal fluvial sands overlain by lacustrine clays which are in turn overlain with alternating and inter-fingering sequences of alluvium and colluvium. These alluvium/colluvium layers can vary widely in thickness, largely depending on the location within the palaeodrainage system, and have been locally replaced by calcrete across broad areas.

The orebody at Yeelirrie is largely hosted in calcrete which occurs within the upper 10 m of the profile; therefore only the most surficial sediments are of interest to the mining operation in terms of overburden management. However, a thorough understanding of the formation (both geometry and sediment fill) of the entire palaeovalley and drainage system is critical to the understanding and management of other aspects of the project, including the hydrogeological system. All of the primary lithologies which have been described are discussed in detail within Section 6.2 of the PER. The formation history which has resulted in the palaeodrainage system is summarised below in ascending chronology.

Basement Geology (Archaean)

Regionally the crystalline basement is composed of NNW-SSE trending “greenstone” belts, typically composed of poly-deformed, ultra-mafic to mafic intrusives and extrusives, acid volcanics and both clastic and chemical sediments (WMC, 1975). The greenstone belts are intruded and enveloped by extensive metamorphosed felsic to intermediate granitoids and ortho-gneiss variably dated between 2,900 and 2,500 Ma, collectively called “granite terrane” in the literature, which make up the bulk of the northern portion of the craton (Cameron, 1990).

Regolith Development (Oligocene to early Miocene)

The Archaean basement rocks across the area have undergone extensive weathering under prolonged humid tropical climatic conditions during the Oligocene to early Miocene period. This resulted in the development of a deep lateritic profile consisting of a red, ferruginous and siliceous concretionary cap underlain by extensively leached and weathered kaolinite-dominated, saprolitic clay transitioning with lessening degrees of weathering into the underlying bedrock. In the area surrounding Yeelirrie, this lateritic surface is often preserved as relicts topped by siliceous caps, occurring as regional topographic highs often defining the margins of catchment areas.

The lithologies that comprise the greenstone belts are generally more susceptible to weathering than those of the granite terranes, often displaying zones of elevated secondary permeability associated with faulting and shearing. Regolith development therefore tends to extend to greater depths within the greenstone belts in comparison with the granite terrane. The mineralogy of the upper portions of the regolith profile is dominated by iron and manganese oxides, quartz, kaolinite, illite and minor montmorillonite (smectite). In the deeper parts of the profile where the basement is only partially weathered, minerals like muscovite and K-feldspar are often preserved. Mafic minerals generally are only found within the unweathered basement rocks.

Palaeovalley Formation (Miocene/Pliocene)

Rejuvenation of the drainage resulted in the development of a new surface formed through incision and erosion of the regolith profile. This new surface consisted of a system of broad, shallow, south-easterly draining palaeovalleys (WMC, 1975) one of which is the Yeelirrie catchment.

The Yeelirrie catchment is approximately 75 km long and is on average 30 km wide. The valley margins are defined by 5 to 10 m high breakaways outcropping in an otherwise highly subdued terrain. There are multiple first order channels incised into the sides of the main valley draining off of the basin margins, and coalescing into one main channel down the axis of the catchment. Studies completed by WMC, BHPB and URS demonstrate that the basement topography of the Yeelirrie channel is highly variable both across and down catchment.

Infill Sedimentation (Tertiary-Quaternary)

Formation studies completed by Johnson *et al.* (1999) and URS (2011b) in both the Yeelirrie and adjacent catchment areas, suggest the earliest fill deposited (during the Tertiary) were fluvial, with the river systems initially largely confined to the deepest parts of the incised valley. Sedimentary units on the margins of the central channel were dominated by alluvial fans sourced from lateritic breakaways. These fans spread outwards and eventually interfinger with the main channel fill.

In the early Quaternary seasonal surficial water inflow was no longer confined to the basement palaeo-topographic lows, resulting in the formation of an ephemeral braided river system. The resultant sedimentation consists of a sequence of inter-fingering sandy and clayey alluvium units. This drainage system and the accompanying sedimentation cycle were changed as conditions became more arid; resulting in blockage of the trunk valleys.

This aridity resulted in predominantly aeolian sedimentation, consisting of a sand dominated loam, fixed by plant matter to create a loose soil. The current surficial drainage system consists of ephemeral streams linking a series of small playa lakes in topographic depressions developed parallel to, but often offset from, the palaeochannel axis.

Carbonate System (Quaternary)

The main calcrete body within the Yeelirrie channel can be described as a valley calcrete formation. These are known to form in large catchments with a low topographic relief (gradients of < 1%), and are developed in highly to semi-arid environments characterized by irregular, heavy but infrequent rainfall (Mann, 1978).

The carbonate unit within the resource area which has been confirmed by drilling is approximately 11 km long and 2 km wide and, on average, 6 m in thickness. It is generally overlain by 1 – 2 m of surficial sediments but does outcrop in some areas.

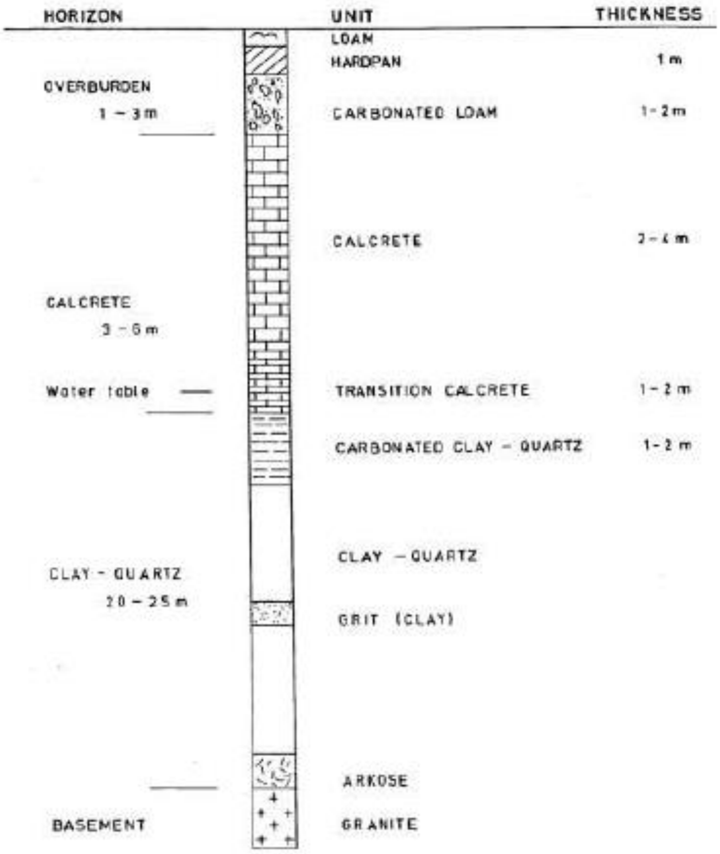
7.3.3 GEOCHEMICAL STUDIES

The following material characterisation studies have been conducted within the vicinity of the Yeelirrie deposit, and are also summarised in the PER.

- Geochemical Assessment Tailings and Waste Rock (SRK, 2011) (Section 6.5 of the PER)
- Long-term Contaminant Transport Modelling (Cameco, 2015a) (Section 9.5.5.3 of the PER)

The objectives of these studies were to evaluate the chemical composition of all materials proposed to be stockpiled on site, including tailings, and assess the solute release and potential interaction of these solutes with natural materials outside the storage areas. Samples for testing were collected during sonic drilling in 2009, a total of 20 samples of different materials from within the mine pit area were selected for detailed geochemical testing. A further 2 samples of palaeochannel sands from depths between 55 and 65 m below the deposit and 41 samples from the historic Kalgoorlie tailings storage facility were also collected. As discussed above, only the surficial materials are of interest to the mining operation in terms of material management. Figure 7.1 presents an idealised section showing the Yeelirrie profile and major lithologies, with the base of pit expected to terminate within the clay quartz lithology.

Figure 7.1: Idealised profile of the Yeelirrie deposit (WMC, 1975).



Test work conducted on the samples taken is summarised below;

- **Bottle roll tests**. Tailings, soil and rock samples were contacted with solution (either de-ionised water or ‘barren liquor’ solution) for 72 hours. The tests were undertaken at a liquid:solid ratio of 3:1. For the majority of tests, the headspace in the bottles was occupied by air. For selected samples, tests were conducted with the bottle headspace filled by a mixture of CO2 (10% by volume) and air.
- **Column tests**. Four column pairs have been set up to operate in series. The first column in each pair is open to air and operated such that the material drains down and becomes unsaturated between flushing events. The second column is not open to air and is maintained saturated with solution at all times. Effluent from the first column is used as inflow for the second column in that pair.
- **Aging tests (tailings)**. Fresh tailings slurries were placed in open and sealed flasks, to represent atmospheric as well as anoxic conditions respectively. Series of replicate flasks were prepared so that after 1, 2, 4 and 8 months of contact time, selected flasks could be disturbed and the pore water recovered for analysis.

To support the above testing chemical assay (via acid digestion followed by ICP), mineralogical investigation (via X-ray diffraction), mineral surface investigation (BET surface area and cation exchange capacity) and radiological testing were conducted on representative drill core and tailings samples.

The mineralogical testing showed that carbonate minerals form an important component of the loam, calcrete and transitional lithologies (transition calcrete, carbonated clay quartz). Calcite is present within the loam and hardpan surface materials, whilst dolomite is located at greater depths. Clay minerals are plentiful in all drill samples and vary with depth in the profile. Smectite (including all montmorillonite group clays) is the most dominant clay mineralogy in the near surface loam and clay samples with kaolin also representing a significant proportion. Deeper in the profile kaolinite dominates along with minor quantities of illite/mica. Similarly to kaolin, quartz is more abundant at depth in the profile, whilst the other accessory minerals identified within the samples included various oxides (goethite, anatase), sulphates (gypsum), carnotite and halite.

A review of the geological database has shown that the majority of metals are present at low concentrations in all lithology groups assayed, with median concentrations below crustal averages as defined by Bowen (1979). The concentrations appear to be lower in the calcrete when compared to clay-quartz lithologies and hardpan, with an apparent correlation between some metals and aluminium/silica content. This suggests that clays may play an important role as sorption sites via ion exchange. The ICP testing conducted by SRK (2011) on representative samples has shown that Arsenic, Strontium and Uranium Oxide were the only components which consistently recorded values higher than the average crustal abundance.

7.3.4 KEY IMPLICATIONS FOR MINE CLOSURE

7.3.4.1 Acid Mine Drainage (AMD) Characteristics

A review of the geological database collected across the Yeelirrie deposit was conducted in order to develop source terms for constituents of concern (COC) for use in solute transport modelling (Cameco, 2015b). Sulphate contents tended to be slightly elevated when compared with average crustal abundances with the majority in the form of gypsum. There was no evidence during mineralogical testing for significant occurrence of sulfide minerals, with ICP testing conducted by SRK (2011) recording average total S levels within waste materials to be very low at 0.05%.

When these results are contrasted with the high carbonate levels found within the loam, calcrete and transitional lithologies which denotes considerable inherent buffering capacity within the majority of materials to be mined, the potential for AMD to occur is considered to be low.

7.3.4.2 Neutral Metaliferous Drainage Characteristics

Bottle leach, column and tailings age testing was conducted on mine waste and tailings material (SRK, 2011). This test work was used to determine likely solute release levels to inform solute transport modelling from proposed stockpiles of waste material and tailings storage cells (Cameco, 2015a). The results of this testing indicate that contaminants released from mine waste (i.e. stockpiled material) at significant concentrations include boron, barium, molybdenum, strontium, thallium, uranium, vanadium and zinc. Although these constituents reported elevated levels, the relatively low levels within the solid phase materials mean that solute release is finite and rapidly decreases with subsequent pore volume exchange cycles, whilst sorption onto iron and aluminium oxy-hydroxides and clay minerals is expected to further limit release of a range of elements.

When the results of solubility leach testing were compared to average groundwater quality monitoring results the concentrations of most solutes were lower within the leaching tests. This suggests that solute release is occurring mostly from salinity that would have been present within the pore water of the samples.

7.4 SOIL AND LANDFORM CHARACTERISTICS

The land systems surrounding the Yeelirrie project have been mapped at a regional scale by the Department of Agriculture and the Department of Land Administration as part of a larger program designed to classify land aridity and aid in resource evaluation across Western Australia. Two reports have been generated which deal with regions surrounding the Yeelirrie project:

- 1988-1990 Survey and condition assessment of the north-eastern goldfields (Pringle, 1994)
- 1992-1993 Survey and condition assessment of the Sandstone-Yalgoo-Paynes Find area (Payne, 1998)

A number of field studies have been conducted across the area to further refine soil-landscape relationships and gather data on soil characteristics. Two principal surveys have been completed which assess the soil and landform characteristics at the Yeelirrie project:

- Soil survey conducted in March, 2010 by Blandford & Associates Pty Ltd (2011). Investigation involved the excavation of 41 soil inspection trenches located in areas representative of the land systems to be impacted and other areas warranting further investigation.
- Soil investigation conducted in April, 2015 by Soilwater Consultants (SWC, 2015a) involved the excavation of 15 soil inspection trenches within the project area along with a further 6 surrounding Lake Mason. The objectives of this study were to investigate the soil profile where populations of *Atriplex* sp. Yeelirrie Station were present to aid translocation studies and additionally gather key information on soils and overburden material for the purposes of closure planning.

Information gathered during these studies which is relevant to closure of the project is summarised below, whilst further information is available in Section 7.5 of the PER.

7.4.1 TOPOGRAPHY

The Yeelirrie uranium deposit occurs in the central drainage channel of a wide, flat and long drainage valley flanked by granitic breakaways of low topographic relief; including the Barr Smith Range to the north-east and the Montague Range to the west.

The valley floor has an elevation of about 500 mAHD, while the breakaways are 50 to 100 m higher. In the vicinity of the deposit, the valley is 25 to 30 km wide. The valley itself runs northwest to southeast and extends at least 50 km to the north-west and approximately 80 km to the southeast, where it joins the Lake Miranda basin at 460 m AHD.

Surface gradients are very low and while the total valley has an overall slope angle of approximately 3.5% on the north-eastern side and 5% on the south-western side, the edges of the valley floor are generally around 0.3 to 0.4%. Longitudinal gradients are typically less than 0.1%.

7.4.2 LANDFORMS AND LAND SYSTEMS

The proposed Yeelirrie Project Area can be divided into three soil-landscape systems:

- Sand plains – This system is located on the outer edges of the project area, extending from the granite breakaways of the old plateau down towards the centre of the drainage valley.
- Playa – this system covers a wide proportion of the project area and acts as a conduit for surface water flow during storm events. It is made up of a series of interlinking areas with gently undulating contours.

- Calcrete – This system is highly localised and exists as slightly raised areas of the central valley floor which run approximately parallel to the central valley axis. The calcrete system outcrops in scattered areas and generally exists at or near the surface (i.e. top 1 m of profile). It should be noted that the calcrete formation exists below the other systems, in particular the playa system; however it occurs deeper in the profile and has not resulted in raised relief.

7.4.3 SOIL TYPES

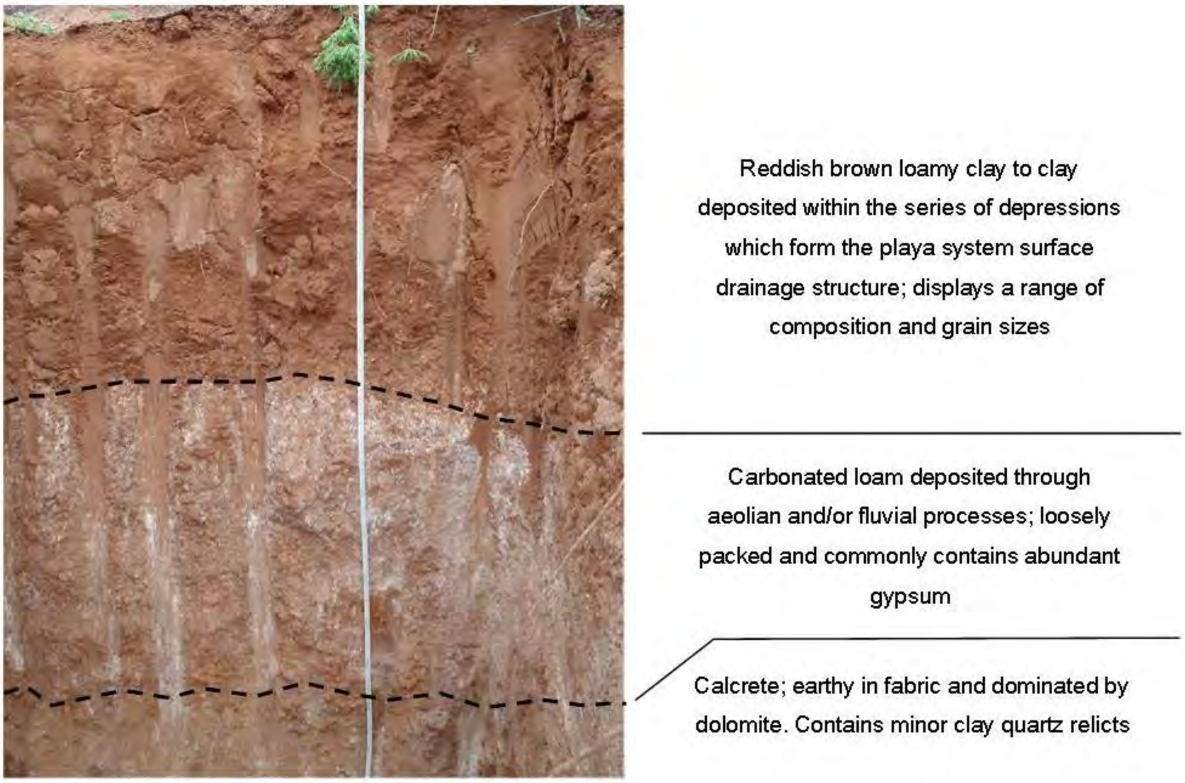
The occurrence of different soil types across the project area is closely linked to and controlled by the land systems discussed above. Of the three land systems, the playa system is the most variable in relation to the differing soil profiles which occur within this system. This variability is caused by the complexity of the unit itself, which is formed by a series of depressions which are not continuously connected to each other and therefore have developed independently to a large extent, with local erosion / deposition events dominating over regional processes. The playa system occurs as a transition zone between the calcrete and sand plain systems.

The sand plain system is likewise largely controlled by geomorphic processes which insert various elements into the profile, with frequent ferricrete and gravels from outwash fans and breakaways mixed with sands of varying grain sizes.

Deeper more significant disturbance (i.e. the mine pit footprint) is confined to the calcrete system, with only surficial disturbance of soils within the other two land systems. Therefore the collection and analysis of closure data has focussed on those soil units which occur within the calcrete system.

Although the individual profiles across the calcrete system do vary, a typical profile within the land system can be said to consist of calcareous loam of variable thickness over transitional calcrete (Plate 7.1).

Plate 7.1: Typical soil profile of a clay pan area within the calcrete system



The calcareous loam is rarely evident on the surface and is instead covered with either a variable thickness of clay (approximately 0.4 m) or a thin cover of loamy sand depending on the position within the landscape (depression vs inter-depression). In scattered areas the calcrete does outcrop and presents as a discontinuous surface gravel or lag of weathered remnants of formation where the finer particles have been physically transported.

The soil units present above the calcrete formation which occur across the calcrete system can be broken down into broad soil units with relatively persistent measured physical and chemical properties throughout. Whilst variability within each unit does exist, these broad categories can be expected to behave in a relatively uniform manner during operations and rehabilitation activities and therefore can be assigned to overall management groups for closure planning:

Loamy Sand

This material occurs on the surface directly above the carbonated loam in areas outside of the clay flats and calcrete outcrops. It generally consists of a loosely packed, friable silty loam to loamy sand, with common gypsum crystals and rounded quartz grains. The material has an alkaline pH between 8 and 9 and low salinity < 100 mS/m. It generally exists in an unsaturated condition and is freely draining.

Clay

This material occurs on the surface directly above the carbonated loam in the clay flats and depressions of the calcrete system. It consists of a self-cracking clay to clay loam, with high plasticity. The measured cation exchange capacity (CEC) varied between 15 and 50 meq/100g indicating the clay fractions is likely to have a moderate to good structural resilience (i.e. shrink/swell potential). Bulk X-ray diffraction (XRD) and clay testing on the clay material showed the clay mineralogy to be composed largely of hydroxyl inter-layered smectite and kaolinite with a large quartz fraction and, accessory K-feldspar (alumino silicate) and iron and titanium oxides. The material generally displays a slightly alkaline pH around 8 and highly variable salinity from < 100 to > 2000 mS/m. Significant rainfall had occurred prior to the time of investigation and the material displayed a dry, fluffy and sometimes crusty upper layer of aggregates approximately 5 to 10 cm thick, below which the clays retained more moisture and had not aggregated.

Carbonated Loam

This alluvial material underlies the loamy sand and clays and is aeolian and/or fluvial in nature. It consists of a very to moderately friable brownish white to pale brown loam with occasional pisolitic nodules and abundant carbonate nodules. It consistently displays an alkaline pH between 8 and 10 and generally has a moderate to high salinity, ranging from approximately 200 to 800 mS/m.

Calcrete

The upper calcrete material is earthy and composed of dolomite, calcite and smectite, with common amorphous black silica. It varies in hardness from soft to hard where porcelaneous silica alteration has occurred, but is dominantly medium to soft in hardness with < 10 % clay quartz present. Where the material has outcropped weathering has removed the finer fractions, leaving behind hardened and indurated gravel to sand size fractions.

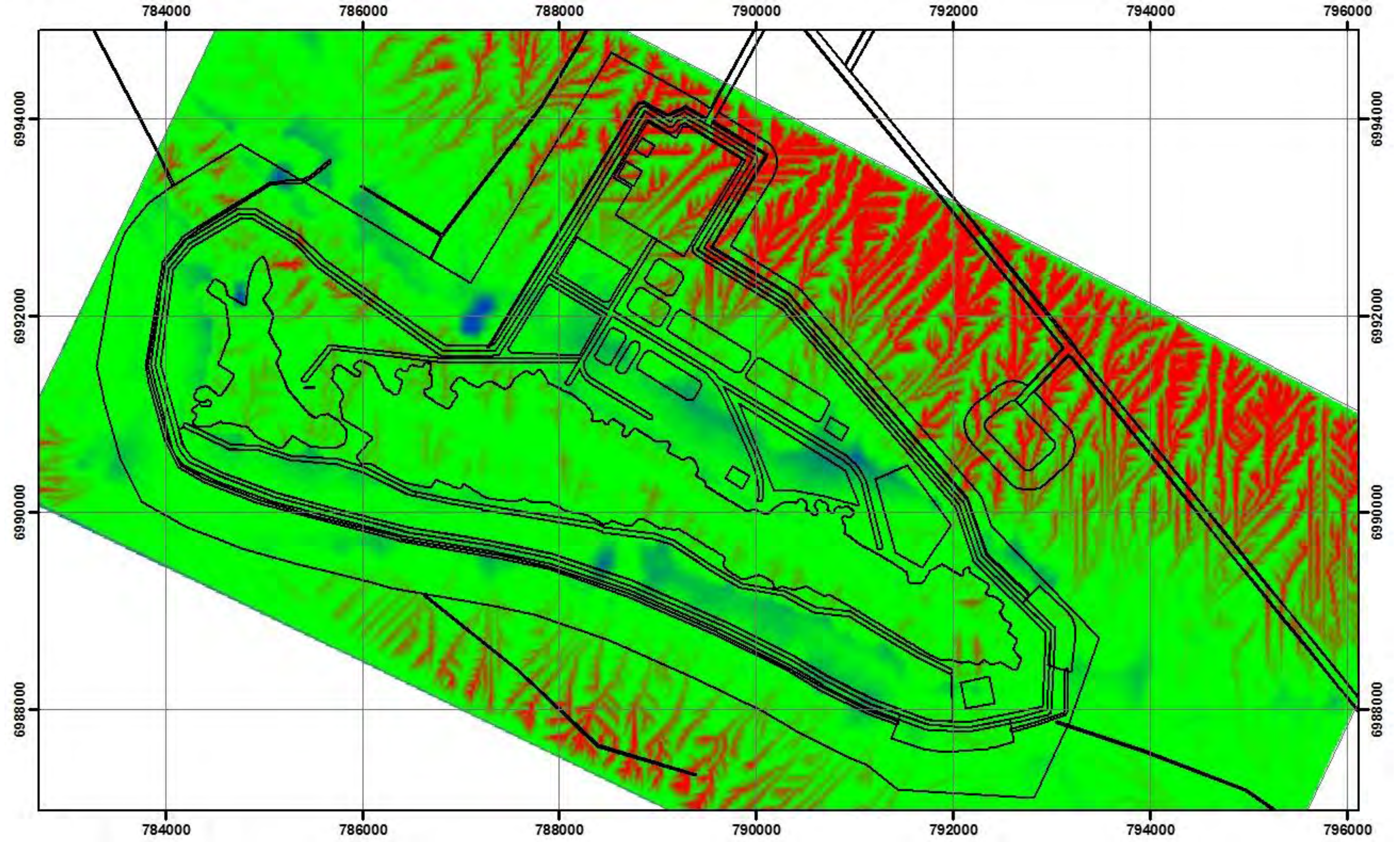
7.4.4 EROSION POTENTIAL

The major material types listed above were tested for their erosive potential under laboratory conditions. A laboratory-scale rainfall simulator was used to measure the interrill (raindrop impact) erodibility whilst the rill erodibility and critical shear stress of the materials under overland flow conditions was tested using a 1.8 metre-long erosion flume. The details of the laboratory testing are provided within the study report (SWC, 2015b) and further detail is provided in Section 9.9 of the PER.

The results from laboratory scale testing were used to conduct landform evolution modelling using the SIBERIA model over a 10,000 year climate scenario. Two model runs were conducted; one using the clay material and one the carbonated loam soil as the primary cover material. The final model output of this modelling was a predicted DEM at 10,000 years post-closure, where a time varying constant was applied such that soil erodibility values are constant for the first 100 years of the simulation, and decrease to 1/10th of the original values thereafter to simulate vegetation establishment and sediment eluviation. Figure 7.2 depicts the result of this modelling on the carbonated loam material.

In general, both of the tested cover materials resulted in similar soil movement over the model period. In both cases, the majority of sediment loss was predicted to occur on the valley slopes, with a net deposition occurring in many areas of the valley floor near the rehabilitated landform. Some gullying of the backfilled profile is evident, but due to the very gentle land slopes (i.e. typically ≤0.25°, or 4 m elevation change per km), this is not widespread. The “time-varying erodibility” model scenarios showed similar patterns of soil movement to the “base case” scenarios, although the overall volume of soil eroded was smaller. In the case of both scenarios diffusive sediment transport (i.e. raindrop impact erosion) appears to be the dominant erosion mechanism.

In terms of overall stability of the soil material system, losses of less than 0.5 m were predicted over approximately 75-80% and 80-85% of the former TSF area for the surficial clay and surficial loam, respectively. This indicates a relatively stable land surface, with an annual average erosion rate of less than 0.05 mm/year over 80% of the TSF surface. Additional gullying occurred in some locations around the perimeter of the landform, with maximum gully depths approaching 1.5 m depth after 10,000 years in both of the modelled materials, although the extent of gullying was greater in the clay. Despite this, the majority of the soil over the rehabilitated TSF cells remained relatively in-tact, with gullying only occurring in some areas.



Cameco Australia

Yeelirrie Uranium Project Mine Closure Plan

Figure 7.2: Overall change in elevation predicted by SIBERIA "time-varying erodibility" model, surficial loam at 10,000 years post-closure

Cameco

7.4.5 PERFORMANCE OF TSF COVER DESIGN

Unsaturated zone modelling was conducted using HYDRUS to investigate the performance of the conceptual TSF cover design. Of particular interest is the expected rate of moisture flux through the cover system which will in turn control the rate of recharge of the individual TSF cells. This has important implications for the contaminant transport modelling which has been conducted (Cameco, 2015a). The conceptual TSF model which was tested consists of a 1 m thick capillary break constructed from clean and mineralised calcrete which is in turn covered by a 2 m thick layer of loam (Figure 7.3). The cover design is described in greater detail in Section 9.

Rainfall data was gathered from the nearby Wiluna weather station for use in the model. A continuous record of daily rainfall and evaporation data was available for a 14 year period between April 1972 and May 1985 (inclusive). Average annual rainfall depth during this period was 237 mm/yr, which is essentially equal to the long-term average of 238 mm/yr. Average annual evaporation during the modelled period was 2,121 mm/yr, which is less than the long-term average of 2,412 mm/yr, making infiltration of water into the profile above average during this period. Six large storm events were included in the record for this period, four events approximating a 1:10-yr ARI storm event (85 mm rainfall in 24 hrs), and two events approximating a 1:5-yr ARI storm event (70 mm in 24 hrs). In addition a 1:100 yr ARI storm event (equating to 158 mm in 24 hrs) was inserted into the climate record to simulate high rainfall and ensure the model included the expected range of rainfall ARIs.

The HYDRUS model predicted approximately 17 mm of infiltration over the 14-year model period. This equates to an average of approximately 1.2 mm/yr seepage through the TSF cells. This rate of infiltration is within the range of infiltration scenarios used to conduct the contaminant transport modelling (see Section 7.6.12), and the cover system is therefore expected to effectively limit infiltration of water into the TSF cells to a relatively small quantity for which the potential impacts are understood.

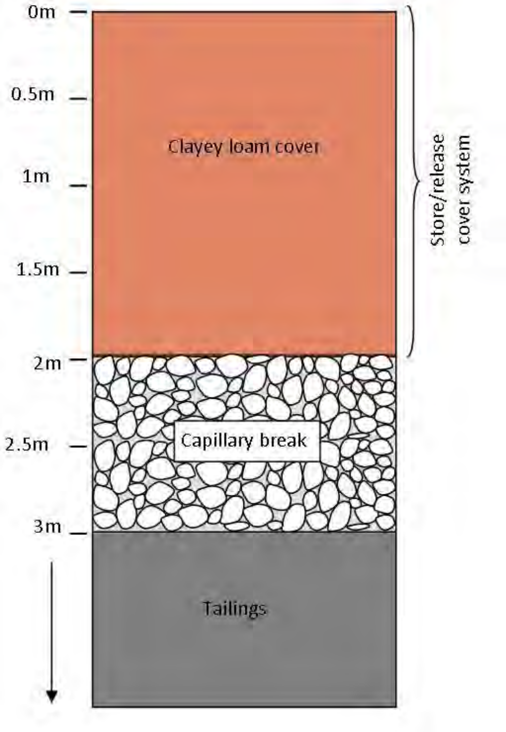


Figure 7.3: Conceptual cover design used in HYDRUS unsaturated zone modelling

7.4.6 IMPLICATIONS FOR MINE CLOSURE

- The measured properties of the soil materials to be disturbed and stored for the project can be handled as three separate units of clay/loam, calcrete, and the underlying sediments (clay-quartz).
- Calcrete which does not form part of the orebody will form a valuable resource for use in constructing a capillary break over the in-pit TSF's and should be preferentially stored and designated for this use.
- The clay/loam material will allow a store/release cover to be developed over the TSF which will limit infiltration of rainfall to acceptable levels and provide a valuable growth medium which will encourage revegetation growth and rehabilitation.
- Erosion modelling of the clay/loam material shows this material to be moderately erosive over the long term. The modelling indicates that the hydrological regime which currently exists can be expected to be reinstated, with minor to moderate local, short scale erosion dominating landform evolution but no long term net sediment loss or movement occurring.

7.5 SURFACE WATER

7.5.1 SURFACE WATER STUDIES

A detailed Surface Water Study was completed in 2011 in order to characterise the local and regional surface water environment, and to aid in the preparation of monitoring and management plans (URS, 2011a). This study was updated in 2015, to incorporate a modified site layout and to include probable maximum precipitation (PMP) event scenarios (URS, 2015). An understanding of the hydrological setting for the study area was gained by several methods, including a literature review and several field studies, conducted between March 2009 and January 2011. This information was then used to develop a conceptual hydrological framework for the region and a numerical hydrological model for the local site area. The model was used to simulate the surface water flow regime (e.g. development of flow hydrographs and flood maps) under various climatic scenarios for the existing (baseline) conditions and during the operational and post-closure phases of the proposed development.

7.5.2 REGIONAL SURFACE WATER ENVIRONMENT

The regional surface water environment is described in detail in the *Surface Water Study* report (URS, 2015). In summary, the proposed development is within the semi-arid Murchison bioregion, and more specifically within the Yeelirrie valley catchment, a low, wide, flat palaeo-valley flanked by granite ranges (breakaways). The region receives an average annual rainfall of 238 mm and has an annual pan evaporation rate of 2,412 mm. Ephemeral drainage lines carry stormwater from the breakaways to the valley floor, but there are no permanent watercourses or stock dams within the project area or adjacent properties. Rain events typically lead to localised sheet flows and short-term surface ponding in clay pans and playas before the water evaporates or infiltrates. Storm events that result in widespread flooding that fill the major salt lakes in the region occur primarily as sheet flows and are uncommon.

7.5.3 LOCAL SURFACE WATER ENVIRONMENT

The Yeelirrie Catchment drains to the southeast into Lake Miranda. Generally, the valleys between the breakaways are broad with very little relief, except towards the western and northern portions of the catchment, where low hills of basement rocks occur, with an average relief of about 40 m. Side valley slopes (0.3% to 0.5%) and longitudinal valley slopes (0.1 to 0.2%) are comparatively gentle, typically increasing to about 1% at the foot of the breakaways.

The Yeelirrie Catchment area has been broken down into five "catchment units", used to describe the various surface water flow patterns observed in the catchment:

- Breakaway – catchment margins with relatively steep slopes and numerous incised drainages
- Wash plain – hard pan plain, topographically at a lower elevation beneath the breakaways, with shallow, incised watercourses
- Sand plain – broad sand plain on catchment foot-slopes with little or no relief or defined drainage lines
- Playa – low-lying playa and hard pan-dominated landscape along the central valley floor, particularly within the central and downstream reaches of the Yeelirrie catchment
- Calcrete – flat or slightly raised landforms typically present along the central valley floor. The landscape is commonly raised, reflecting an active accretion setting of chemical deposition.

Table 7.5 presents the proportional make-up of the Yeelirrie playa catchment with respect to the five main catchment units. Similar to the broader Lake Miranda Catchment, the wash plains and sand plains constitute about 80% of the Yeelirrie playa catchment. The Yeelirrie Deposit lies at the base of the broad valley, primarily within playa and calcrete catchment units. The central calcrete unit forms a slight rise in the middle of the valley, and any surface flows are thus expected to form two parallel channels on either side.

Table 7.5: Summary of "catchment units" within the Yeelirrie Playa Catchment

Catchment unit	Yeelirrie Playa Catchment		Lake Miranda Catchment	
	Area (km^2)	% of catchment	Area (km^2)	% of catchment
Breakaway	814	18	1,255	17
Wash plain	1,104	24	2,131	28
Sand plain	2,518	54	3,634	48
Playa	146	3	280	4
Calcrete	58	1	260	3
TOTAL	4,640	100	7,560	100

7.5.4 INFILTRATION TESTING

Infiltration tests were completed across the Lake Miranda Catchment, intending to differentiate between the primary soil types identified within the five catchment units described in Table 7.5. A total of 27 double-ring infiltration tests were conducted, and the results of this testing are summarised in Table 7.6. This information was used to frame the flood modelling inputs (i.e. it provided loss rates for the initial loss/continuing loss model).

Table 7.6: Infiltration test results summary

Catchment Unit	Number of Sites	Number of Tests	Field Infiltration Rate (m/day)	
			Range	Mean
Breakaway	0	0	-	-
Wash Plain	9	10	3.6 – 7.9	5.8
Sand Plain	11	13	3.6 – 13.7	10.8
Calcrete	2	2	1.1 – 3.6	2.3
Playa/Clay Pan	2	2	0 – 0.3	0.2

7.5.5 FLOOD MODELLING

Peak flow and flood modelling was conducted within the proposed development area for various size storm events, ranging up to the Probably Maximum Precipitation (PMP) event (URS, 2015). The results of modelling indicate:

- Flood events smaller than 1:20 year ARI generate only localised sheet flow runoff. No interconnected flows are predicted to occur within the catchment valley.
- Larger flood events (1:20 to 1:100 year ARI) generate interconnected runoff in the valley floor throughout the Lake Miranda catchment terminating in the playas.
- Extreme flood events (1:100 year ARI and greater) generate runoff throughout the Lake Miranda catchment, with Lake Miranda spilling over into the Lake Carey catchment.

Modelled pre-development flooding was relatively modest, owing to the broad, gentle nature of the catchment, and was estimated at ≤ 1.0 m depth for the 1:100-yr ARI event and ≤ 2.5 m depth for the 1:1,000-yr ARI event upstream of the development area.

Flood depth was also modelled for the post-closure landform. A digital elevation model (DEM) of the proposed post-mine land surface was used as the key input to the model, with all other hydrological and meteorological properties remaining the same as the pre-development and operational scenarios. The post-mine landform has been designed with a slight rise in the centre (1-2 m above the surrounding land surface), and shaped specifically to mimic the hydrologic regime resulting from the in situ calcrete ridge. Continuity of flow has been maintained in both of the parallel flow channels running on either side of the deposit, although the northern channel has a smaller width than the pre-mine valley. Elevation cross-sections, comparing the pre-mine and proposed post-mine landforms are presented in the surface water study report (URS 2015), figures 7-3 to 7-6.

Peak flow and flood modelling were conducted within the proposed development area for various size storm events, ranging from the 1:1-yr ARI event up to the PMP event. A summary of key results of the post-closure model is presented in Table 7.7 and Table 7.8, and are compared to the results of the baseline hydrological assessment.

In general, the post-closure model predicted flood depths that were slightly greater directly upslope of the deposit (see “upstream reaches”), with downslope flood depths generally unaffected (see “downstream reaches”). The upslope effect was typically greatest in the northern flow channel, owing to the slightly restricted shape of this channel as compared to the pre-mine landform. The greatest increases in predicted flood depth occurred at the location of the restriction of flow, on the north-eastern corner of the deposit (see “Yeelirrie Playa”). The southern flow channel was less affected, with flood depth changes within ±0.25 m of baseline.

Similarly, peak flood flow velocities were not predicted to vary significantly from the baseline, at locations upstream and downstream of the deposit. Predicted changes in velocity were < 0.2 m/s in these areas. However, increased flow velocity is expected at the location of the restriction in the northern “Yeelirrie Playa” flow channel. Velocity was predicted to increase on the order of 0.2 – 0.4 m/s for storm events up to the 1:1,000-yr ARI event, as compared to baseline. This is considered to be a relatively modest increase and, given the relatively low overall flow velocities (generally less than 0.8 m/s at all locations), is not expected to result in significant changes to sediment erosion or deposition rates in this area.

Flood waters are not expected to overtop the backfilled TSF area for flood events of less than the 1:100-yr ARI event. All flood larger than this will likely overtop the TSF area.

Table 7.7: Modelled post-closure peak flood depth

Event ARI	Simulated maximum flood depth (m)			Simulated difference from baseline (m)		
	Upstream Reaches	Downstream Reaches	Yeelirrie Playa	Upstream Reaches	Downstream Reaches	Yeelirrie Playa
1:20-yr	≤ 0.5	≤ 0.5	0.5 – 1.0	0.10 – 0.25	-0.1 – 0.10	0.10 – 0.25
1:100-yr	1.5 – 2.0	0.5 – 1.0	1.5 – 2.0	0.10 – 0.25	-0.1 – 0.10	> 2.0
1:1,000-yr	2.0 – 2.5	1.5 – 2.0	2.0 – 2.5	0.25 – 0.50	-0.1 – 0.10	1.0 – 2.0
PMP	> 5.0	> 5.0	> 5.0	0.25 – 0.50	-0.1 – 0.10	> 2.0

Table 7.8: Modelled post-closure peak flood flow velocity

Event ARI	Simulated maximum flow velocity (m/s)			Simulated difference from baseline (m/s)		
	Upstream Reaches	Downstream Reaches	Yeelirrie Playa	Upstream Reaches	Downstream Reaches	Yeelirrie Playa
1:20-yr	0.0 – 0.2	0.0 – 0.2	0.0 – 0.2	< 0.2	< 0.2	< 0.2
1:100-yr	0.2 – 0.4	0.2 – 0.4	0.4 – 0.6	< 0.2	< 0.2	0.2 – 0.4
1:1,000-yr	0.6 – 0.8	0.6 – 0.8	0.6 – 0.8	< 0.2	< 0.2	0.2 – 0.4
PMP	0.8 – 1.0	1.0 – 1.5	1.0 – 1.5	0.2 – 0.4	< 0.2	0.6 – 0.8

7.5.6 SURFACE WATER QUALITY

Opportunistic surface water sampling was completed at six sites during two rainfall events that occurred in 2009 and 2010. The results of which are discussed in detail in Section 9.4 of the PER. In general, surface water quality was found to be widely variable, but indicated the potential to host relatively high salinity, suspended solids, and metals concentrations.

Field and laboratory results showed that the sampled surface waters were neutral to slightly alkaline (pH = 6.5 to 9.6) and fresh to saline (TDS = 23 to 16,800 mg/L). Typically, salinity and major ion concentrations are low in the headwaters of the catchment and increase along flow paths, but the water remains fresh within the upper catchment. The highest salinities occurred in association with the Yeelirrie and Albion Downs playas, where salt is naturally accumulating and strongly influencing the quality of resident waters. These samples are characterised by comparatively high concentrations of sodium, chloride and bicarbonate ions.

The wide variability in surface water quality sample results is also expected to be influenced by the following factors:

- average recurrence interval of the rainfall event
- chemistry of the rainfall
- time since the rainfall occurred and the samples were collected
- presence of various salts in the surface soils upstream of and at the sample locations
- lengths of flow paths before sampling
- energy of the sampled surface water flows
- location in the catchment and catchment units traversed

- sample setting in active watercourses or from ponds.

7.5.7 EXISTING SURFACE WATER USERS

There are no current or expected future third-party users of the surface water resources in the project area because of the unreliability of the flows, lack of potential dam sites and relatively poor water quality.

7.5.8 KEY IMPLICATIONS FOR CLOSURE

- Ephemeral drainage lines carry stormwater from the breakaways to the valley floor, but there are no permanent watercourses or stock dams within the project area or adjacent properties. Thus, management of permanent surface water flows is not required, and the potential for impacts on aquatic environments is non-existent.
- The Yeelirrie Deposit lies at the base of the broad valley, primarily within playa and calcrete catchment units. The central calcrete unit forms a slight rise in the middle of the valley, and the ephemeral surface flows form two parallel channels on either side. The post-mine landform design will need to consider ways to preserve this flow regime.
- Flood modelling of the post-mine landform indicated little to no change in flood flow depth and flow velocity, both upstream and downstream of the deposit, as compared to the pre-mine environment. This indicates that any changes to the flooding regime are limited to the Yeelirrie Playa area.
- Flood depths and velocity were predicted to increase within the Yeelirrie Playa area, as compared to the pre-mine environment. The greatest increases are expected at the location of a restriction of flow, on the north-eastern corner of the deposit. Velocity was predicted to increase on the order of 0.2 – 0.4 m/s for storm events up to the 1:1,000-yr ARI event, as compared to baseline. This is considered to be a relatively modest increase and, given the relatively low overall flow velocities (generally less than 0.8 m/s at all locations), is not expected to result in significant changes to sediment erosion or deposition rates in this area.
- Flood waters are not expected to overtop the backfilled TSF area for flood events of less than the 1:100-yr ARI event. All flood events larger than this will likely overtop the TSF area. Despite this, flood-flow velocities are expected to remain low (less than 0.8 m/s), and loss of sediment during these rare events is expected to be relatively minimal. However, flooding of the TSF cover system may have follow-on effects on infiltration and leaching through the TSF cells, with longer inundation times resulting in more infiltration.

7.6 GROUNDWATER

7.6.1 GROUNDWATER STUDIES

The following groundwater investigations have been conducted within the vicinity of the Yeelirrie deposit, and are described in more detail in the most recent Groundwater Study report (Cameco, 2015a) and presented in Section 9.5 of the PER:

- Dewatering measurements and hydraulic parameter estimation associated with the “Slot 1” trial mining operation within the Yeelirrie Deposit (AGC, 1973; McKay, 1973).
- Extensive groundwater studies, including borehole drilling and production well construction, were conducted in the area east of the Yeelirrie deposit, resulting in the development of the Albion Downs well field (WMC, 1994; Woodward-Clyde, 1996).
- A ground-based gravity survey was conducted in 2009 to define the deepest parts of the Yeelirrie palaeochannel along selected cross sections in support of optimizing subsequent drilling (Fugro, 2009).

- Installation and monitoring of a groundwater well network was conducted in 2009 and 2010 (URS, 2011b), and consisted of 143 groundwater monitoring wells, 7 nested monitoring wells, 8 test production wells, 95 wells for stygofauna characterisation, and 77 wells for troglofauna characterization. The wells were constructed along 14 planned cross section lines and eight “in-fill” lines within the planned Yeelirrie footprint.
- Pump testing was completed on regional and local bores to obtain an estimate of the hydraulic conductivity and transmissivity of the various hydrostratigraphic units at the site (URS, 2011b). Pump testing included short-term pumping tests of 50 monitoring wells and step-drawdown and 48 hr constant rate pump tests on the eight test production wells.
- Laboratory test were conducted on eight undisturbed core samples from the clayey alluvium to determine vertical hydraulic conductivity (URS, 2011b).
- A conceptual groundwater model and numerical groundwater flow model were developed to assess the potential impacts of the Yeelirrie Project on the groundwater environment (URS, 2011b). This model was updated in 2015 to incorporate a modified site layout and TSF design (Cameco, 2015a).
- Contaminant transport modelling was conducted for five contaminants of concern (COCs) n tailings pore water to assess their potential impact in a post closure environment. (Cameco, 2015a)

7.6.2 REGIONAL ENVIRONMENT

The Northern Goldfields area is underlain by weathered and fractured Archaean bedrock, which forms the northern portion of the ‘Fractured-Rock Groundwater Province’ of the Yilgarn Goldfields (Johnson *et al.*, 1999). A deeply incised palaeodrainage system traverses the region, including a palaeochannel system traversing the length of the Yeelirrie catchment (Yeelirrie Palaeochannel), which forms part of the Carey Palaeodrainage catchment. These palaeochannels and the major associated surficial calcrete bodies form key aquifer zones, with the ore body being located in the calcrete in the central portion of the Yeelirrie valley. The main components of the valley fill identified within the Yeelirrie valley are fractured rock, palaeochannel sand, calcrete and alluvium.

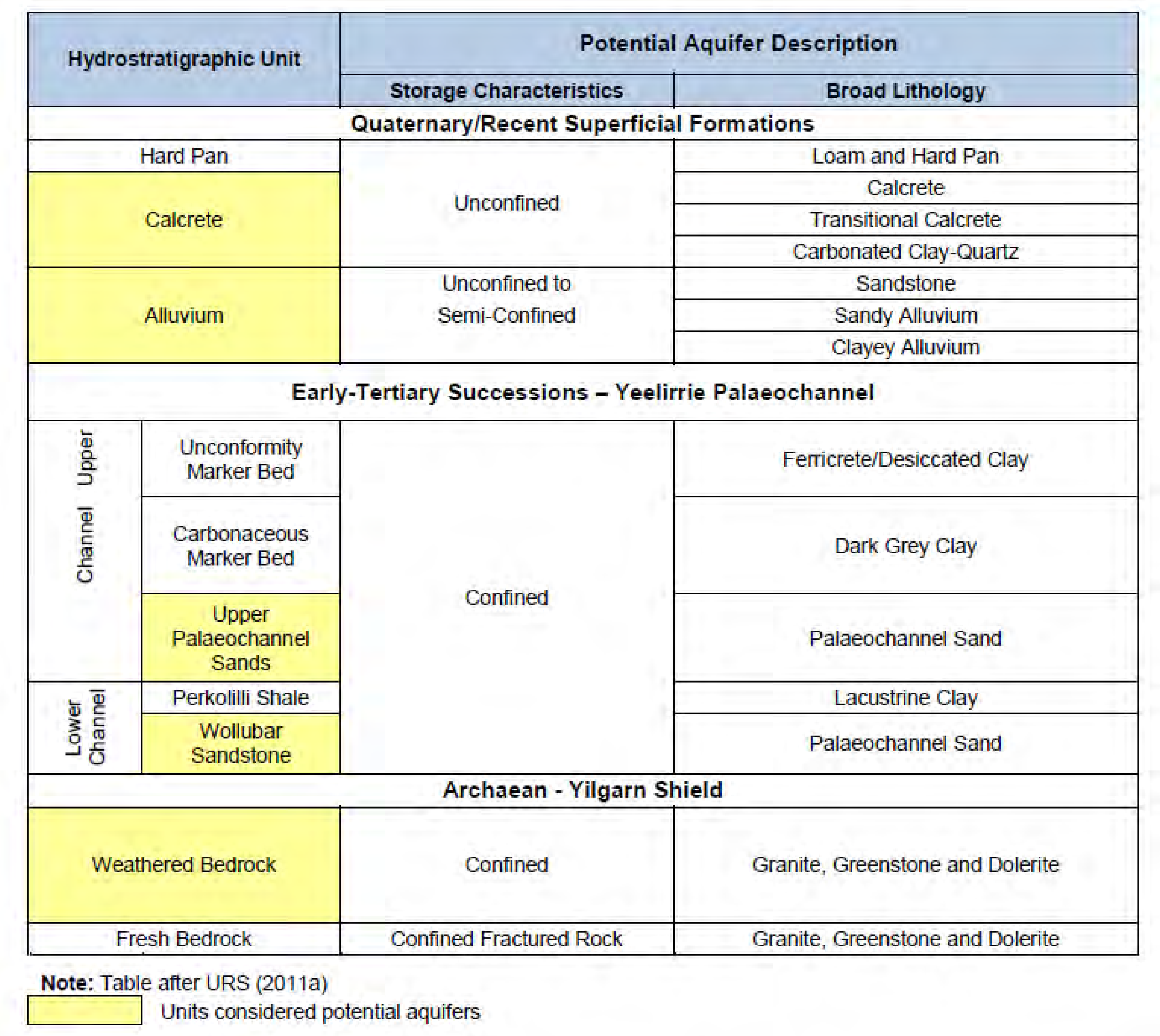
7.6.3 HYDROSTRATIGRAPHY

The interpreted regional and Yeelirrie catchment stratigraphy is summarised in Table 7.9. The primary aquifer types identified within the Yeelirrie Catchment can be categorised into the following groups:

- Calcrete aquifers and other secondary weathering products of shallow sediments (ferricrete/silcrete).
- Alluvial sands/gravels/clays.
- Palaeochannel basal sands.
- Weathered and/or fractured basement rocks.

Hydrogeological assessments to determine aquifer hydraulic parameters were undertaken by AGC (1981) and refined as a result of the 2009-2010 field investigations. The ranges of estimated aquifer parameter values are summarised in Table 7.10.

Table 7.9: Yeelirrie Catchment stratigraphy

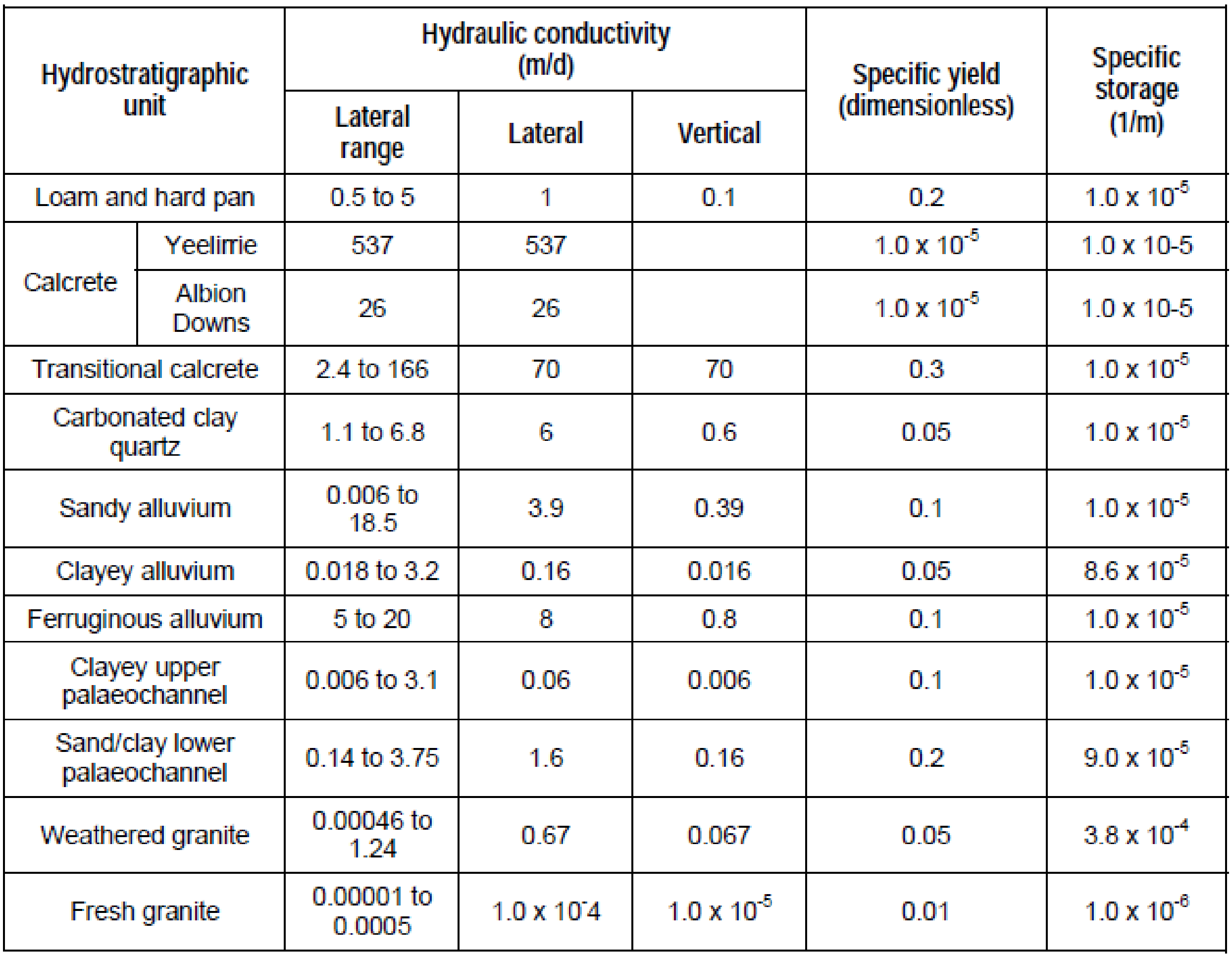


Hydrostratigraphic Unit		**Potential Aquifer Description**	
		Storage Characteristics	**Broad Lithology**
Quaternary/Recent Superficial Formations			
Hard Pan		Unconfined	Loam and Hard Pan
🟨 Calcrete			Calcrete
			Transitional Calcrete
			Carbonated Clay-Quartz
🟨 Alluvium		Unconfined to Semi-Confined	Sandstone
			Sandy Alluvium
			Clayey Alluvium
Early-Tertiary Successions – Yeelirrie Palaeochannel			
Channel Upper	Unconformity Marker Bed	Confined	Ferricrete/Desiccated Clay
	Carbonaceous Marker Bed		Dark Grey Clay
	🟨 Upper Palaeochannel Sands		Palaeochannel Sand
Lower Channel	Perkolilli Shale		Lacustrine Clay
	🟨 Wollubar Sandstone		Palaeochannel Sand
Archaean - Yilgarn Shield			
🟨 Weathered Bedrock		Confined	Granite, Greenstone and Dolerite
Fresh Bedrock		Confined Fractured Rock	Granite, Greenstone and Dolerite

Note: Table after URS (2011a)

🟨 Units considered potential aquifers

Table 7.10: Summary of effective aquifer parameters



Hydrostratigraphic unit		Hydraulic conductivity (m/d)			Specific yield (dimensionless)	Specific storage (1/m)
		Lateral range	Lateral	Vertical		
Loam and hard pan		0.5 to 5	1	0.1	0.2	1.0×10^{-5}
Calcrete	Yeelirrie	537	537		1.0×10^{-5}	1.0 x 10-5
	Albion Downs	26	26		1.0×10^{-5}	1.0 x 10-5
Transitional calcrete		2.4 to 166	70	70	0.3	1.0×10^{-5}
Carbonated clay quartz		1.1 to 6.8	6	0.6	0.05	1.0×10^{-5}
Sandy alluvium		0.006 to 18.5	3.9	0.39	0.1	1.0×10^{-5}
Clayey alluvium		0.018 to 3.2	0.16	0.016	0.05	8.6×10^{-5}
Ferruginous alluvium		5 to 20	8	0.8	0.1	1.0×10^{-5}
Clayey upper palaeochannel		0.006 to 3.1	0.06	0.006	0.1	1.0×10^{-5}
Sand/clay lower palaeochannel		0.14 to 3.75	1.6	0.16	0.2	9.0×10^{-5}
Weathered granite		0.00046 to 1.24	0.67	0.067	0.05	3.8×10^{-4}
Fresh granite		0.00001 to 0.0005	1.0 x 10-4	1.0×10^{-5}	0.01	1.0×10^{-6}

7.6.4 BASELINE GROUNDWATER LEVELS

Considerable effort has been placed into characterising the baseline (pre-development) water table elevations within the Yeelirrie Catchment, as this constitutes a key reference for calibration of the groundwater model. Groundwater elevations collected from regional pastoral wells, pre-development water level data at the Albion Downs well field, and data collected during the 2009/2010 Yeelirrie groundwater census were mapped, and are presented in the Groundwater Study report (Cameco, 2015a). The interpreted water table topography closely reflects the land surface topography. Groundwater moves from the catchment divides towards the valley floor areas and then in a general southeast direction towards the Yeelirrie Playa, Albion Downs Playa, and Lake Miranda.

Depth to the water table has also been mapped, and is presented in the Groundwater Study report (Cameco, 2015a). The greatest depths to the water table are found in the headwater area of the catchment and along the flanks. In these areas the depth to the water table ranges from 10 to 20 m below ground surface and locally is greater than 20 m. Along the valley floor, the depth to the water table is typically less than 5 m. Within the area of the deposit the depth to the water table is in the 3 to 5 m range.

7.6.5 BASELINE GROUNDWATER QUALITY

Details of baseline groundwater quality survey information are provided in the 2011 Groundwater Study report (URS, 2011b). In summary, the baseline data indicate that the Yeelirrie Catchment is host to a wide variety of groundwater qualities. The baseline salinity of groundwater in the Yeelirrie Catchment varies from fresh (<1,000 mg/L TDS), brackish and suitable for stock (<4,000 mg/L TDS) to saline and locally hypersaline (>40,000 mg/L TDS). In the water table zones, groundwater is fresh beneath upper catchment areas characterised by the breakaway catchment unit. Down-gradient, beneath wash plain and sand plain catchment units, the groundwater is typically brackish and of <4,000 mg/L TDS suitable for stock. Beneath valley-floor areas characterised by calcrete, hard pan and playa catchment units, the groundwater is increasingly saline and locally hypersaline (>40,000 mg/L TDS). Typically, the accumulation of salt in the groundwater environment is reflected by commensurate accumulations of major ion, dissolved metals, nutrients and, at least, in the Yeelirrie Catchment heightened radiological activities linked to the occurrence of carnotite.

Dissolved uranium is present in all of the hydrostratigraphical units. Overall, the concentration ranges from less than detection limit (<0.001 mg/L) to 2.4 mg/L. Within the deposit, the average uranium concentration is 0.29 mg/L (± 0.32 mg/L) and in the palaeochannel sediments it is 0.74 mg/L (± 0.69 mg/L). The dissolved vanadium concentration is typically less than the detection limit (0.01 mg/L). Bromide is present in significant concentrations (up to tens of milligrams per litre) in all hydrostratigraphical units.

Most measured activities of radon exceed the stock water guideline value (0.1 Bq/L) by at least an order of magnitude. More detail on radiation in groundwater is provided in Section 9.5 of the PER.

7.6.6 EXISTING GROUNDWATER USERS

The largest groundwater user in the Yeelirrie Catchment is the Nickel West Mt Keith Operation, which abstracts water from the Albion Downs well field. This well field, starting about 30 km east of the Yeelirrie deposit, consists of 32 production wells, spaced apart about 1.6 km, and stretches over a distance of about 51 km. The Albion Downs well field has been in production since 1994, and supplies an average of approximately 20,000 kL/day (about 7.5 Gl/a).

Other minor uses of groundwater in the area are discussed in Section 9.5 of the PER, and include primarily pastoral activities.

7.6.7 GROUNDWATER RECHARGE

Natural Recharge

A detailed assessment of aquifer recharge is included in the 2011 Groundwater Study report (URS, 2011b). In summary, water level monitoring data indicates that aquifer recharge is highly sporadic and localized, and that up to 50 mm of rainfall, or more, is required for recharge to occur. Average aquifer recharge rates of 0.40-0.80 mm/yr were derived for inclusion in the groundwater model through an assessment of the baseline water table elevations, water and salt balances, evaporation and transpiration rates, surface water availability, measurement of infiltration rates, and monitoring of water table fluctuations linked to rainfall events. The derived recharge values fall within the range of values reported in the literature, as reviewed by URS (2011b).

Mining Area

As outlined in Section 2.6.1, approximately 10 m depth of native soil and overburden material, covering an area of approximately 10 km^2 and consisting primarily of surface loam, calcrete, and carbonated clay quartz, will be removed as part of the mining process. The resulting mine void will be backfilled with process tailings, and covered with an engineered cover system prior to rehabilitation, as described in Section 9. This modification of the natural stratigraphy is expected to result in a recharge rate that differs from the surrounding environment, and this will have an effect on potential solute leaching and subsequent transport through the groundwater system.

As discussed in more detail in Section 7.4.5, a HYDRUS model was developed to estimate the expected annual infiltration of water through the TSF cover system, given local climate data and known materials properties. The model infiltration through the cover system would average 1.2 mm/yr. This is greater than the assumed background level of recharge, 0.4 mm/yr, however, it is within the range of recharge rates included in the TSF contaminant transport model (i.e. 0.2 – 6.0 mm/yr) (see Section 7.6.12). Therefore, while infiltration is increased from background levels, the cover system is expected to effectively limit infiltration of water into the TSF cells to a relatively small quantity for which the potential impacts are understood.

7.6.8 DEWATERING ESTIMATION

As outlined in Section 2.6.1, dewatering blocks and associated trenches will be used to lower groundwater levels within the proposed mine pit to at least 1 m below the pit floor in order to provide a safe working environment within the pit. The dewatering strategy was assessed using a computer model of the system (Cameco, 2015a), and installation of dewatering trenches to 3 m below the average pit floor were found to be suitable for this purpose.

The predicted annual pit dewatering volumes range from 0.04 to 2.6 GL/yr (Mm^3/yr) during the project, resulting in a total volume of 18.62 GL (Mm^3) being extracted from the surficial aquifer during operations. The groundwater model predicted that the drawdown cone resulting from this dewatering activity could extend up to approximately 3 km beyond the mine pit (0.5 m contour line), and the maximum extent of the dewatering cone is expected to occur at the end of the mining operation (i.e. year 22). In practice, the lateral extent of drawdown resulting from mine pit dewatering will not be discernible from drawdown resulting from the four neighbouring bore fields, as abstraction from these areas will happen concurrently, and the drawdown cones are expected to interact (see Section 9.5 of the PER).

7.6.9 MANAGED AQUIFER RECHARGE

Pit dewatering volumes will exceed operational water demands in the early stages of the project when the mill operation has not started. In order to conserve groundwater, a Managed Aquifer Recharge (MAR) system is included in the design to manage the variable flows of water from drainage. The MAR concept involves injection of surplus water from pit dewatering into the calcrete for temporary underground storage and subsequent re-extraction.

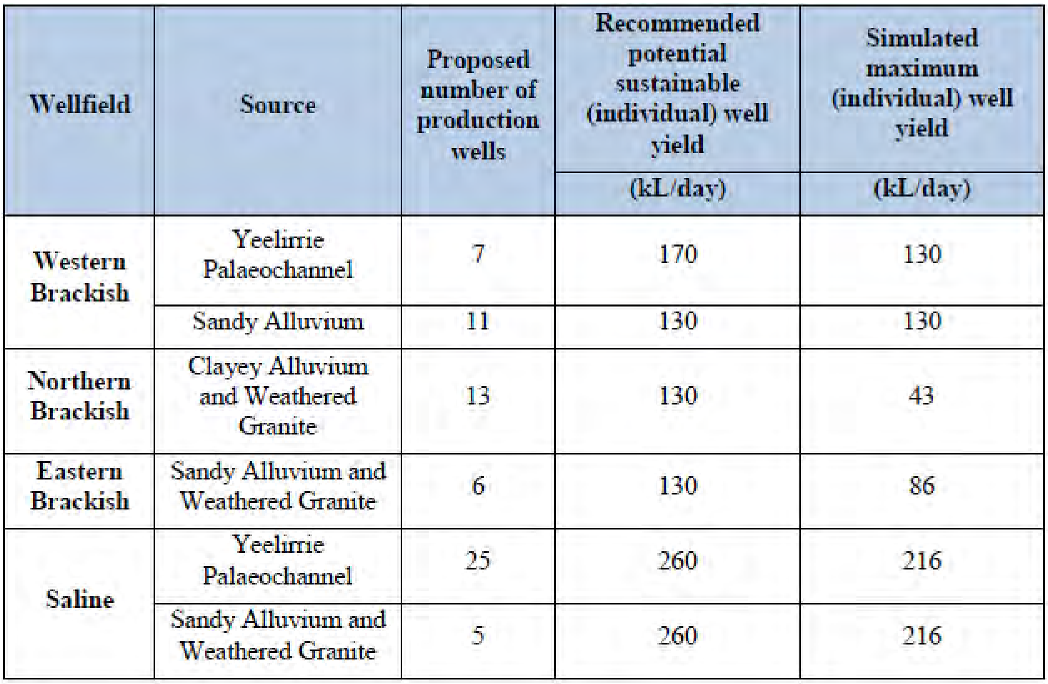
Groundwater re-injection through MAR system was modelled, and is expected to cause groundwater mounding around the injection well site, with a predicted maximum groundwater level increase of approximately 1 m occurring locally. Groundwater level increases last for 4 years until the drawdown from production well fields counters the increase. The re-injection point is located with the open pit area and the area impacted by an increase in groundwater levels will be subject to groundwater drawdown from groundwater production well fields and ultimately mined. As the MAR system would be abandoned once the pit dewatering abstractions drop below the operational water demand (year 4), no residual groundwater mounding is expected by site closure (year 22).

7.6.10 WELL FIELD ABSTRACTION

Four well fields are proposed to be developed to meet the balance of operational water demand that is not able to be met by the abstracted dewatering water. A summary of the four proposed well fields is provided in Table 7.11, and the proposed layout is presented in the groundwater report (Cameco, 2015a).

The predicted annual abstraction volume from the well fields ranged from 0.5 to 2.5 GL/yr (Mm^3/yr) during the project, resulting in a total volume of 47 GL (Mm^3) being extracted during operations. Results of groundwater modelling indicated that the drawdown cone resulting from the well field abstractions was complex, and interacted with the dewatering drawdown cone. The maximum extent of the combined drawdown of the four well fields and the dewatering activity is expected to occur at the end of the mining operation (i.e. year 22).

Table 7.11: Proposed water supply well fields



Wellfield	Source	Proposed number of production wells	Recommended potential sustainable (individual) well yield (kL/day)	Simulated maximum (individual) well yield (kL/day)
Western Brackish	Yeelirrie Palaeochannel	7	170	130
	Sandy Alluvium	11	130	130
Northern Brackish	Clayey Alluvium and Weathered Granite	13	130	43
Eastern Brackish	Sandy Alluvium and Weathered Granite	6	130	86
Saline	Yeelirrie Palaeochannel	25	260	216
	Sandy Alluvium and Weathered Granite	5	260	216

7.6.11 POST-DEVELOPMENT GROUNDWATER LEVEL RECOVERY

At closure, the mined-out pit will be filled with tailings or other backfill wastes and covered with appropriate materials. At that time, all water supply abstractions and drainage will have ceased. Due to the change to the *in situ* geologic medium, and thus to the groundwater flow field and recharge and discharge rates, the groundwater regime in the proposed development area is expected to take some time to reach a new state of equilibrium.

Modelling of the closure period was completed to simulate the groundwater level recovery process around the mine pit and well fields, to estimate the time required for the groundwater systems to reach a new steady state condition, and to identify any residual changes to the groundwater table configuration. The results of this modelling are discussed in detail in the modelling report (Cameco, 2015a), however the general findings can be summarised as follows:

- Groundwater table recovery is evident in the short-term after cessation of abstraction, with the major part of the recovery to baseline levels occurring over a 50-year period.

- Water table recovery is predicted to occur more quickly beneath the valley floor compared to areas higher upslope. For example, the water table at the pit location is predicted to recover to baseline levels within 100 years, but small residual drawdowns would persist in the area of the nearby Northern Well Field for more than 200 years.
- Within the TSF area, the water table recovers to levels about 0.5 m below the baseline elevations. This suggests a new steady state due to the local geologic medium property changes.

While some minor changes in the down-valley groundwater flow path are expected at the local scale in the vicinity of the pit, no permanent changes in groundwater level were predicted. This is somewhat counterintuitive, as a large volume of calcrete material (which is highly porous and conductive, $K \approx 500$ m/d) will be removed from the mining zone, and replaced with tailings cells (which have a very low conductivity, $K = 10^{-4}$ m/d). It might be expected that down-gradient groundwater flows would “back up” upstream of the TSF cells. However, the geologic cross-sections indicate that reasonably contiguous “high” transmissivity sands exist directly to the south of the pit area; at their narrowest, they are approximately 2 km wide, and extend approximately 20 m below the water table. This sandy alluvium therefore represent 8-10 times the cross-sectional area of the calcrete aquifer that is to be removed from the mining area, and it is therefore expected that this strata has sufficient capacity to avoid any “backing up” of water upstream of the TSF cells. This is supported by the hydrological model results.

7.6.12 POST-DEVELOPMENT GROUNDWATER QUALITY

Predictive long-term transport modelling has been conducted with the objective of assessing the movement of selected constituents of concern (COCs) in tailings pore water and their potential impact in a post closure environment.

Selection of COCs

Investigations have been conducted to characterize the constituents of concern in the future tailings to be deposited in the in-pit TSF cells (Cameco, 2015b), and the estimated concentration and distribution coefficient (Kd) of five selected COCs (chloride, uranium, vanadium, arsenic, and molybdenum) are described in Table 7.12. These COCs were chosen because:

- As and Mo are expected to be the least retarded in the Yeelirrie hydrogeological environment because they exist as negatively charged species
- U and V are of particular concern because of the geochemistry of the carnotite deposit.
- Chloride is included because it is a non-retarding conservative tracer.

Table 7.12: COC source terms and distribution coefficients (K_d) for the Yeelirrie In-Pit TSF

Constituent	Cameo Source Term (mg/L)	Distribution Coefficient, K_d	
		Loams	Clay-quartz
Cl	26,000	0	0
U	180	420	1.1
V	79	480	2.7
As	4.6	350	1.3
Mo	2.1	47	0.67

Base Case Model Results

Major findings of the predictive long-term (15,000-year) solute transport models include:

- The predicted conservative chloride plume could travel as far as 50 km to the east of the project area, mainly along the valley, with elevated concentration (>10 mg/L) in very limited local areas, and low concentration (< 10 mg/L) in most areas. Beyond a distance of 1,000 m west of the deposit the increase is negligible compared to the baseline concentrations.
- Other simulated COCs (including uranium, vanadium, arsenic and molybdenum) are predicted to travel in the order of several hundred meters longitudinally along the valley. This limited transport is due to sorption of COCs to solid geologic medium.

High Infiltration Model Results

Sensitivity analyses were performed to evaluate the impact of input parameters on transport modelling results. The model was found to be most sensitive to Kd, extinction depth, and variations in the groundwater recharge rate. Given the high degree of uncertainty in the predicted recharge rate for the engineered TSF cover system at the time the groundwater modelling was completed, a large range of recharge rates was modelled to cover the range of anticipated scenarios (recharge rates of 0.24 mm/yr up to 6 mm/yr). When the recharge rate to the groundwater through tailings and backfill cover was increased from 0.1% of average annual rainfall to 2.5% (0.24 to 6.0 mm/yr, respectively), the following results were obtained:

- The maximum eastward extent of the chloride plume front (0.01 mg/L) did not change significantly, but the width of the plume was shown to increase.
- While the extent of the Chloride plume was not significantly affected, chloride concentrations in groundwater increased significantly.
- The maximum extent of the predicted Uranium, Vanadium, Arsenic, and Molybdenum plumes increased significantly. The Uranium plume was predicted to extend approximately 6 km to the east (0.2 mg/L contour); compared to the several hundred metres predicted by the base case model.
- Downward transport of contaminants to the deeper model layers (e.g. Layer 8: weathered granite) also increased.

As discussed in Section 7.4.5, a HYDRUS model of the engineered cover system predicted 1.2 mm/yr seepage through the TSF cells. This rate of infiltration is within the range of infiltration scenarios used to conduct the contaminant transport modelling, and the cover system is therefore expected to result in a transport regime in between the modelled “base case” (infiltration of 0.24 mm/yr) and “worst case” (infiltration of 6 mm/yr) scenarios.

7.6.13 KEY IMPLICATIONS FOR CLOSURE

- The local hydrostratigraphy will be modified by the construction of an in-pit TSF, and groundwater levels will be drawn down across the region during operations, with the maximum extent of drawdown occurring at the time of site decommissioning (year 22).
- Despite the modified hydrostratigraphy, post-mine groundwater levels are expected to return to near pre-mine levels, with the only permanent changes to water levels occurring with the in-pit TSF cells
- Groundwater level recovery outside of the TSF cells will occur over a 50-200 yr time period, with faster recovery occurring within the valley floor setting (i.e. around the mine pit), and slower recovery occurring within the bore field areas.

- Conservative tracer modelling indicates that a non-sorbing contaminant has the potential to travel up to 50 km from the project area over 15,000 yrs post-closure. Sorbing contaminants (e.g. U or V) generally only travel in the order of several hundred metres post closure.
- The predicted long-term transport of sorbing contaminants (e.g. Uranium) in the groundwater system is sensitive to the predicted recharge rate of water through the engineered TSF cover system. Lower estimates of recharge rates (0.24 mm/yr) resulted in travel distances on the order of only a few hundred metres, whilst the higher recharge rate modelled of 6 mm/yr results in a plume extending up to 5 km to the east of the project area (0.2 mg/L contour for Uranium).
- Any changes in groundwater chemistry down-gradient from the Project Area are not likely to affect other groundwater users, as the groundwater is naturally saline and exhibits radiation levels that area already above stock water guidelines (see Section 7.10).

7.7 VEGETATION

7.7.1 FLORA AND VEGETATION ASSESSMENT PROTOCOLS

Local and regional baseline flora and vegetation surveys were conducted between 2008 and 2010 (Western Botanical, 2011), and included the following scope:

- A Level 2 assessment of the flora and vegetation, within “Study Area 1” (includes the project footprint area and the proposed 45 km access road from the Goldfields Highway). This included mapping the vegetation communities at a scale of 1:10,000, mapping the distribution and abundance of significant flora, and establishing and assessing 182 quadrats and 180 relevés to provide a numerical analysis of the variation in the floristic composition of vegetation communities.
- Floristic surveys within “Study Area 2” (consists of five areas extending out from the boundary of study area 1 and includes the proposed quarry site, wellfields and buffers of the project), which included mapping the vegetation communities at a scale of 1:20,000, searching for and recording the extent of significant species.
- Floristic surveys within “Study Area 3” (Yeelirrie and Albion Downs Station, 30 km south-east of the proposed project footprint), which included mapping the vegetation communities at a scale of 1:10,000, and mapping the distribution and abundance of significant flora, with particular focus on *Atriplex* sp. Yeelirrie Station.
- Undertaking regional surveys to provide a regional context for the distribution of flora species and vegetation communities of conservation significance or interest that were recognised within Study Area 1. This included the species of interest and communities primarily associated with calcrete.

See Section 9.1 of the PER for details of the survey site and assessment methods used in the baseline surveys.

7.7.2 REGIONAL FLORA AND VEGETATION

The regional setting of the Yeelirrie project is described in detail in Section 9.1 of the PER. In general, the East Murchison subregion of the Murchison Biogeographic Region is dominated by Mulga (*Acacia aneura*) woodlands, hummock grasslands, saltbush shrublands and *Halosarcia* (now *Tecticornia*) shrublands. The region contains many land systems, which identify a recurring pattern of topography, soils and vegetation.

7.7.3 VEGETATION COMMUNITIES

In total, 52 vegetation communities were identified and mapped for the local study area. They have been grouped broadly as occurring within one of five soil landscape systems as follows (note that four of these are consistent with the description of soil landscape systems provided in Section 7.4, Soil and Landform Characteristics, with ‘hardpan and drainage system’ added to refine the description of vegetation communities):

- Sand plain system – this system dominates the study area, extending from the central valley to the granite breakaways. Elements are drainage lines from the breakaways, outwash fans, aeolian dunes and the plain itself. Sand plain communities are characterised by Spinifex (*Triodia* spp.) hummock grasslands with a varying amount of shrub, tree and mallee components in the upper stratum. Nine vegetation communities (and one mosaic) were defined within the sand plain system.
- Playa system – this system is a transition zone from the sand plain to the central calcrete system and an important conduit for surface water runoff moving down the valley. Ten vegetation communities are described in the playa system. The majority of this system is vegetated with *Acacia – Ptilotus obovatus* Shrubland (PLAPoS) on flats surrounding playas. PLAPoS forms a mosaic, in which eight other minor vegetation communities occur fringing or within playa depressions, scalds and sink holes. Areas with no vegetation occur in this system and have been mapped as bare ground.
- Central calcrete system – this system occupies the central zone of the valley floor and generally consists of outcropping calcrete in its various forms. Eleven vegetation (and four mosaic) communities, including shrublands, woodlands and grasslands, are described within the Central calcrete system.
- Granite breakaway system – this system has three key units and a highly variable transition zone to the sand plain system. The granite breakaway system units comprise the breakaway plateau surface, the breakaway itself and foot slopes. There are eleven communities of shrubland and grassland described in the Granite breakaway system.
- Hardpan and drainage system – five vegetation communities are described in this system, which forms an inter-zone or continuum between the sand plain and playa systems. These communities are characterised by bare-ground, and are subject to surface water sheet flow following rainfall and significant wind erosion.
- Saline playa system – six vegetation communities are described in this system. Three communities are observed in the lakebed, while the remaining three communities occur on the sandy banks and sloping clay flats. All communities appear to be well adapted to highly variable moisture and salinity conditions.

Western Botanical (2011) provides an overview of the location and extent of each of the vegetation communities mapped for the local study area, and provides a series of figures that illustrates the vegetation mapping at a finer scale to enable a more accurate appreciation of vegetation community boundaries.

7.7.4 THREATENED ECOLOGICAL COMMUNITIES

There are no conservation significant ecological communities in the study area of the proposed Yeelirrie development. That is, there are no Threatened Ecological Communities (TECs) listed under the Commonwealth EPBC Act or the Western Australian Wildlife Conservation Act 1950, and there are no listed Priority Ecological Communities (PECs). PECs refer to poorly known ecological communities.

No vegetation complexes listed as TECs occur within 100 km of the project area.

7.7.5 OTHERWISE SIGNIFICANT ECOLOGICAL COMMUNITIES

Five vegetation communities, all occurring on the Central calcrete system within the project footprint, are considered to be otherwise significant as they are, based on current information, of limited distribution or are closely associated with ecosystems described by Cowan (2001) to be at risk in the East Murchison subregion. The five vegetation communities of interest are:

- *Atriplex* sp. Yeelirrie Station Shrubland on Calcrete (CApS) – new community recorded during the ERMP studies and not documented to date
- *Rhagodia* sp. Yeelirrie Station Shrubland on Calcrete (CRsS) – new community recorded during the ERMP studies and not documented to date
- *Eucalyptus gypsophila* Woodland on Calcrete (CEgW) – closely associated with the at risk Calcrete platform woodlands/shrublands of the north-east Goldfields ecosystem described by Cowan (2001)
- *Casuarina pauper* Woodland on Calcrete (CCpW) – closely associated with the 'at risk' Calcyphytic Casuarina – Acacia woodlands/shrublands of the north-east Goldfields (Pringle et al. 1994 – site type 7) and the above-mentioned Calcrete platform woodlands/ shrublands of the north-east Goldfields
- *Melaleuca xerophila* Shrubland on Calcrete (CMxS) – closely associated with the 'at risk' Melaleuca sp. nov (now Melaleuca xerophila) low closed to open forest strand community near Wiluna ecosystem described by Cowan (2001).

7.7.6 GROUNDWATER-DEPENDENT VEGETATION

Groundwater dependent vegetation (or phreatophytic vegetation) is deep-rooted and can access groundwater, via the capillary fringe. For the purposes of this assessment, a conservative approach has been adopted where obligate vegetation (i.e. vegetation that only inhabits areas where they can access groundwater) and facultative vegetation (i.e. vegetation that access groundwater for at least some portion of their environmental water requirement) have been considered to be groundwater dependent.

The following communities contain species that are potentially groundwater dependent:

- *Acacia* spp. and *Eremophila* spp. Thicket (PLAET)
- *Acacia* spp. and *Melaleuca interioris* Shrubland (PLAMi)
- *Melaleuca xerophila* Shrubland on Calcrete (CMxS)
- *Melaleuca interioris* Shrubland on Calcrete (CMiS)
- Mulga and *Grevillea berryana* Shrubland on Calcrete (CMGbS)
- *Casuarina pauper* Woodland on Calcrete (CCpW)
- *Eucalyptus gypsophila* Woodland on Calcrete (CEgW)
- Sand Plain Spinifex Hummock Grassland with *Eucalyptus gongylocarpa* Woodland (SAGS)
- Sand Plain Spinifex Hummock Grassland with *Corymbia lenziana* Woodland (SACSG).

7.7.7 CONSERVATION SIGNIFICANT FLORA

No species were identified from the Commonwealth EPBC Act protected matters database search, and no species were recorded during the field surveys.

No species were identified from the Declared Rare Flora (DRF) database search (Western Australia WC Act) and no DRF species were recorded during the field surveys.

Five WA Department of Environment and Conservation (DEC) Priority 1 species were identified from the database search, and four were recorded during the field surveys, which included one from the database and three additional species (total of eight species identified). Of these, only two species were found within the project footprint:

- *Atriplex* sp. Yeelirrie Station (not in the DEC database, but identified during field surveys) (now listed at *Threatened*)
- *Rhagodia* sp. Yeelirrie Station (not in the DEC database, but identified during field surveys)

7.7.8 OTHERWISE SIGNIFICANT FLORA

Flora species considered to be otherwise significant are listed as Priority 3 or 4 species by the WA Department of Environment and Conservation (i.e. species not currently under threat but under consideration for a higher listing) or a species considered to be of local significance to the project area. 36 otherwise significant species were identified during database searches, or recorded during the field surveys. Of these; 16 species were found within the project footprint:

- *Euryomyrtus inflata*
- *Baeckea* sp. Sandstone (C.A. Gardner s.n. 26 Oct. 1963)
- *Bossiaea eremaea*
- *Eremophila arachnoides* subsp. *arachnoides*
- *Olearia arida*
- *Comesperma viscidulum*
- *Scaevola spinescens* terete leaf form (G. Cockerton & C. Ringrose LCH 14560)
- *Templetonia incrassata*
- *Acacia* sp. Yakabindie (G. Cockerton & G. O'Keefe LCH14274) aff. kempeana
- *Acacia* sp. (G. Cockerton & R. Graham LCH25491)
- *Eremophila* sp. Wiluna (G. Cockerton & K. Stratford 1983)
- *Prostanthera* sp. Bullimore sandplain (G. Cockerton & D. True 12813)
- *Eremophila subfloccosa* subsp. aff. lanata (G Cockerton & C Jowett 25337)
- *Acacia aneura* (multiple variants)
- *Bertya dimerostigma*
- *Eragrostis* sp. Yeelirrie Calcrete (S. Regan LCH 26770)

More detail discussion about these species can be found in Western Botanical (2011) and Section 9.1 of the PER.

7.7.9 WEEDS AND DECLARED PLANTS

Eleven introduced flora species were recorded in the local study area. None of the species are listed as a 'Declared Plant' under the Agricultural and Related Resources Protection Act 1976 (Department of Agriculture and Food 2009).

The weeds recorded are generally non-aggressive species, however the presence of *Acetosa vesicaria* (Ruby Dock) in areas rehabilitated in 2004 is a concern, as these areas could act as a weed seed source in the future. Ruby Dock is a common weed along roadsides and in disturbed areas, and widespread in the north-eastern Goldfields and Murchison regions. Ruby Dock is competitive in rehabilitation areas and requires active management to be controlled successfully.

7.7.10 ATRIPLEX STUDY

During the baseline flora surveys conducted in 2011, a new species of *Atriplex* was identified. Named *Atriplex* sp. Yeelirrie Station, it was found at only two locations, one which coincides with the footprint of the orebody and the second some 30 km to the south east. The population over the orebody is not able to be avoided and would be destroyed by the mine, whilst the second population will be protected by Cameco.

Work carried out since the discovery has shown that there is significant genetic difference between the plants of the two populations. More recent studies have determined that while the plants are likely to be of the same taxon, the two genotypes should be preserved. Further studies have since been carried out to consider aspects that would contribute to a successful relocation of a population of *Atriplex* to maintain the genetic diversity of the species. The studies include:

- Seed harvesting, viability, storage and germination testing
- Population dynamics of the natural population
- Hydrogeology of the natural habitat and of potential sites for relocation
- Ecophysiology of the species.

The results of this work is summarised in *Conservation Species Management Plan* (Western Botanical, 2015) and discussed in Section 9.1 of the PER. The Management Plan also presents a program of future work which would be undertaken to support the relocation program if the Yeelirrie project was approved.

7.8 TERRESTRIAL FAUNA

7.8.1 FAUNA ASSESSMENT PROTOCOLS

The following fauna surveys were conducted to determine the fauna values of the site and to assess the significance of impacts under Commonwealth and Western Australian legislation:

- Level 2 Vertebrate Fauna Assessment (BCE, 2011)
- Short-Range Endemic Invertebrate Baseline Survey (Ecologia, 2011)

An assessment of the radiological effects on non-human biota has also been conducted (BHP, undated), and is discussed briefly in Section 7.10, *Radiation*, and in Section 9.3 of the PER.

7.8.2 VERTEBRATE FAUNA

A desktop review identified 292 vertebrate fauna species that may be expected to occur in the study area (10 frog, 88 reptile, 155 bird, 31 native mammal and eight introduced mammal species). The BCE field surveys in 2009 to 2010 recorded a total of 196 of these fauna species. This comprised four frog, 49 reptile, 82 bird, 21 native mammal and four introduced mammal species. These are discussed in more detail by BCE (2011) and in Section 9.3 of the PER. Identified Conservation Significant Fauna are discussed in Section 7.8.4.

Eight introduced vertebrate species are likely or have been confirmed to utilise the study area based on the desktop review and fauna surveys. These are the Red Fox *Vulpes vulpes*, Cat *Felis catus*, House Mouse *Mus musculus*, Rabbit *Oryctolagus cuniculus*, Goat *Capra hircus*, Donkey *Equus asinus*, Horse *Equus caballus* and Camel *Camelus dromedaries*. Introduced species may be relevant to the native fauna assemblage through effects of predation and/or competition and habitat degradation.

7.8.3 INVERTEBRATE FAUNA

The database searches for invertebrate fauna identified 74 species from the wider region, including 41 mygalomorph spider, 17 scorpion, 6 pseudoscorpion, 4 snail and 9 centipede species. A total of 1679 invertebrate specimens were collected during the baseline field survey, and these represented 42 species. Identified species are discussed in more detail by Ecologia (2011). Identified Conservation Significant Fauna are discussed in Section 7.8.4, and SREs are discussed in Section 7.8.5

7.8.4 CONSERVATION SIGNIFICANT FAUNA

Vertebrate Fauna

Thirty-five species of conservation significance are considered likely to occur in the study area. Of these, 20 are of high significance (Conservation Significance [CS] Level 1), being listed under legislation; seven are of moderate conservation significance (Conservation Significance Level 2), being listed as priority species by the Department of Environment and Conservation (DEC); and eight are of local significance (Conservation Significance Level 3), because they have restricted distributions or are listed as declining species in the region.

Even among species that were recorded, the significance of their presence in the project area is considered to be minor in most cases because the species is considered to be an irregular visitor (16 species), a resident but very widespread (e.g. Peregrine Falcon, Australian Bustard, Square-tailed Kite) or there is little, if any, habitat actually within the study area (eg. Great Desert Skink, the legless lizard Aprasia picturata, Long-tailed Dunnart, Kultarr).

For six significant species, the study area may be of moderate importance. These are:

- Malleefowl - population known in region and considered to be significant by Benshemesh and Dennings *et al.* (2008)
- Black-flanked Rock-Wallaby - population known in region
- Slender-billed Thornbill - may be present with suitable habitat within the study area but only a small proportion in impact areas
- Brush-tailed Mulgara – large local population found by BCE (see below)
- Bush Stone-curlew – local population found by BCE (see below)
- Greater Long-eared Bat – species found in area by BCE and suitable roosting habitat (tree hollows) within and close to the resource

Most of the recorded significant species were found in low numbers and/or outside the resource area. The Brush-tailed Mulgara, however, was abundant in areas of open Mixed Shrubland on Spinifex sandplain across the Project area, with low densities recorded in some parts of the resource area. The Malleefowl population on Yeelirrie Station is significant (Benshemesh *et al.*, 2008), and is likely to be confined to Acacia shrublands on sandplain in higher landscapes. One inactive mound was found by BCE approximately two kilometres north of the centre of the resource area and other mounds were found by the Malleefowl Preservation Group well to the north and south of the Project area, the closest being approximately 15 km from the centre of the resource area.

Invertebrate Fauna

A total of 18 species are listed by the EPBC Act, WC Act or DEC priority list to occur in the Midwest and Goldfields areas including three arachnid, four crustacean, ten insect and one mollusc species. None of these species were found during the surveys completed for this report.

7.8.5 SHORT RANGE ENDEMIC INVERTEBRATE SPECIES

Forty six species were identified in the Malacology and Terrestrial Invertebrate electronic databases representing SRE species that may be found in the region. A total of 42 species were collected within the project area during the baseline SRE survey (Part One), of which three species were confirmed SREs (*Idiosoma* sp., *Pseudolaureola* sp., and Platyarthridae/Barthytropidae) and 13 were considered potential SREs (*Aganippe* sp., *Aname* 'MYG170', *Aname* 'MYG212', Barychelidae, *Cheridiidae*, *Cubaris* sp. 1, *Cubaris* sp. 2, Geophilida*, Kwonkan* 'MYG171', *Kwonkan* 'MYG172', *Kwonkan* 'MYG210', *Kwonkan* 'MYG211' and *Urodacus* 'yeelirrie'). A subsequent survey of the Yeelirrie Playa and two other playas within the project area found 21 terrestrial invertebrate species including one additional confirmed SRE (*Pseudotetracha helmsi*).

Nine of the 17 SRE species have only been collected from within the project footprint including *Aname* 'MYG170', Barychelidae, Cheridiidae, *Cubaris* sp. 1, Geophilida, *Kwonkan* 'MYG171', *Kwonkan* 'MYG172', *Pseudolaureola* sp. and Platyarthridae/Barthytropidae. A habitat analysis showed no statistically significant difference between SRE species diversity and habitat type inside and outside the project footprint. Hardpan Mulga habitat was the most diverse in SRE species followed by Calcrete Outwash, Calcrete and Mixed Shrubs over Spinifex Sandplain habitats. However, the Calcrete habitat showed the highest specimen abundance followed by Hardpan Mulga, Calcrete Outwash and Mixed Shrubs over Spinifex Sandplain habitats.

All habitat types extend beyond the proposed project footprint indicating a potential for all species to be found outside the project footprint.

7.9 SUBTERRANEAN FAUNA

The arid areas of Western Australia have a rich diversity of subterranean fauna. Surveys in the Yilgarn region began little more than a decade ago and the fauna remains poorly known, although it is the focus of much research (Humphreys and Watts *et al.*, 2009). 105 sites in the Yilgarn are currently listed as Priority Ecological Communities (PEC) by the Department of Environment and Conservation (DEC) on the basis of their subterranean fauna communities. Two such sites occur within the subterranean fauna study area for the proposed Yeelirrie development: the Yeelirrie calcrete groundwater assemblage type on Carey palaeodrainage on Yeelirrie Station (hereafter referred to the Yeelirrie PEC); and the Albion Downs calcrete groundwater assemblage type on Carey palaeodrainage on Albion Downs Station (hereafter referred to as the Albion Downs PEC). Information about the conservation status of these communities, including the Yeelirrie PEC, was incomplete at the time of their listing by DEC and remains so, but they are regarded as having high conservation value. Refer to Section 9.2 of the PER for more information.

7.9.1 SUBTERRANEAN FAUNA ASSESSMENT PROTOCOLS

A desktop review and six field surveys were conducted by BHP Billiton between March 2009 and September 2010 (SE, 2011). A further sampling program was carried out by Cameco in February 2015 (Bennelongia, 2015), and additional studies are ongoing. The Study Area to-date comprises seven zones representing different parts of the palaeochannel system from the margins to the centre and from the northwest (top) to the southeast (bottom) of the local catchment. This sampling effort represents one of the most intensive subterranean fauna surveys undertaken in the Yilgarn region to date.

7.9.2 STYOGFAUNA

Yeelirrie has recorded the highest number of stygofauna species from any comparable area in the Yilgarn region to date. This work is ongoing. Refer to Section 9.2 of the PER for more information, including the most recent summary of specific results.

7.9.3 TROGLOFAUNA

Yeelirrie has recorded the richest troglofauna assemblages currently known from any comparable area in the Yilgarn region. This work is ongoing. Refer to Section 9.2 of the PER for more information, including the most recent summary of specific results.

7.9.4 SPECIES RICHNESS AND DISTRIBUTION

Several of the stygofauna and troglofauna species identified through the Yeelirrie surveys are currently known only from areas where the extent of habitat will be reduced by development of the Yeelirrie Project. The likelihood of these species having true ranges that extend beyond their known ranges within the proposed mine pit or predicted area of groundwater drawdown varies between species. Moderately robust inferences may be drawn from the distribution patterns of related species and proximity of recorded species occurrences to the boundary of disturbance areas that nine species may occur beyond the areas impacted by mining and groundwater abstraction.

The richness of stygofauna and troglofauna species at Yeelirrie is partially attributed to the occurrence of multiple, discontinuous calcrete habitats throughout the palaeochannel (as is known to occur throughout the region). The eco-hydrogeological model for the Study Area indicates the importance of habitat discontinuities and physico-chemical variability (between and within calcretes) as key drivers of the richness of subterranean fauna found at Yeelirrie.

The rich stygofauna and troglofauna assemblages detected at Yeelirrie contribute greatly to the regional understanding of subterranean fauna in the Yilgarn. Based on the low intensity of sampling at most other calcretes in the region, it is unlikely that the high richness detected at Yeelirrie is unique. More detailed investigation (particularly utilising genetic analyses, and methods that target troglofauna) at other calcretes could be expected to reveal other rich assemblages. However, the established regional patterns of species distribution, known as the “calcrete island" hypothesis, were reaffirmed at Yeelirrie, with the majority of species detected at single calcretes only. Based on these distribution patterns, it is unlikely that the majority of species detected at Yeelirrie to date would occur at other calcretes in the region.

7.10 RADIATION

7.10.1 RADIATION STUDIES

An assessment of potential radiological impacts associated with the proposed Yeelirrie development was completed by BHP (BHP, undated) and has been reviewed and updated by Cameco. The assessment was conducted according to international practice as recommended by the International Commission on Radiological Protection (ICRP), the national standards propagated by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA 2005), and the standards of the Western Australia Department of Mines and Petroleum (2010), and included:

- an aerial gamma survey

- radon and radon decay product (RnDP) monitoring
- assessing radionuclide levels in airborne dust
- a radionuclide survey of soils, flora and vegetation
- emissions modelling

Summarised results of the radiation studies relevant to site closure are discussed in the following sections.

7.10.2 EXISTING BACKGROUND RADIATION LEVELS

The Yeelirrie uranium deposit is surface outcropping and, as a result, the region is a naturally enhanced source of radioactive material, gamma radiation, and radon. Background studies, conducted in 2010, found:

- Elevated levels (up to 6.3 uSv/h) of naturally occurring terrestrial gamma radiation were observed directly above the mineralised areas of the project, with levels outside of this area being more typical of levels seen across most of Australia (generally < 0.2 uSv/h).
- Real-time radon gas monitoring indicated that radon levels in the atmosphere generally fell within the range of typical global concentrations (1-100 Bq/m^3). Long-term passive monitoring indicated an average of 33 Bq/m^3 for the region, ranging from 10-64 Bq/m^3 across 50 monitoring locations.
- Measured build-up of RnDP was relatively low, with a low average equilibrium factor of 0.2, indicating a high degree of natural dispersion in the air.
- Radionuclide concentrations were elevated in the groundwater in the region of the ore body, and generally decreased with distance from the mineralised zone. Groundwater is not a source of radiation exposure to humans or animals, as the water is highly saline (i.e. not potable).
- The region had generally enhanced concentrations of radionuclides in soils compared to the UNSCEAR average (2-6 times the UNSCEAR values), with the highest concentrations occurring above the mineralised areas.
- Limited fauna monitoring indicated elevated levels of radionuclides in sheep and kangaroo, as compared to animals from other areas in Western Australia.
- Flora monitoring of select species indicated that radionuclide concentrations in plant material was generally higher closer to the mineralised area. Bush tucker results are significantly lower for ^{210}Pb.

The result of the background studies were used to conduct a detailed radiation source assessment, which quantified the total expected radiation dose for workers and members of the public from all of the identified potential radiation sources are presented in Sectoin 9.6 of the PER. Radiation doses were calculated to be less than 10 mSv/y for all mine workers (occupational limit is 20 mSv/y). Doses for members of the public were expected to be low, with the highest doses being for non-radiation workers in the accommodation village at Yeelirrie (0.038 mSv/y, compared to the dose limit of 1 mSv/y).

7.10.3 POST-MINE RADIATION ASSESSMENT

As the uranium deposit is already surface outcropping, and all mine waste and process tailings will be placed back in the mined-out void, the amount of radioactive material near the land surface is not expected to be significantly increased by mining activity. Ambient radiation doses to human receptors will be similar to the pre-mine environment.

The most significant dispersion pathway for radionuclides resulting from the project is expected to be via project-generated dust, and this has potential implications for flora and fauna in the vicinity of the project. A Tier 1 ERICA assessment was therefore undertaken to determine potential dose rates to the surrounding environment. An atmospheric dispersion model was used to map the predicted dust plume, which is expected to extend no further than approximately

5 km from the operational site areas (0.1 g/m^2/month contour). A highly conservative maximum radiation deposition rate of 5 g/m2/month was used in the model, resulting in a corresponding increase in soil radionuclide concentration of 50 Bq/kg.

The Tier 1 ERICA study concluded that only 1 of the 14 organism families assessed (lichens and bryophytes) was likely to exceed the screening dose rate of 10 uGy/h. Lichens in particular do not have a well-developed root system, and derive most of their nutrients from dust falling on them. Consequently, they might be expected to receive a higher dose from the fallout of mine and processing dust, than is the case for other organisms. However, a subsequent Tier 2 assessment concluded that lichens are extremely radio-resistant, with a threshold no-effect dose rate over 10,000 times the default screening rate. Lichen and bryophytes are therefore not considered to be at significant risk of impact.

7.11 CULTURAL HERITAGE

7.11.1 ABORIGINAL HERITAGE

The Aboriginal heritage of the project area has been studied since planning for the development of the Yeelirrie uranium deposit began in the mid-1970s. Over the past 30 years, discussions with local Aboriginal people and collaborative field surveys have resulted in a greater appreciation of the Aboriginal cultural heritage values within the project area. This process is documented in detail in the PER.

While the wider Northern Goldfields region contains many archeologically and culturally important sites (registered sites under the Aboriginal Heritage Act 1972), no listed or otherwise significant sites have been identified within the project footprint.

There are no registered native title claims covering the project area. The Tjiwari claim is currently being considered by the Federal Court.

7.11.2 NON-INDIGENOUS HERITAGE

The Northern Goldfields region is rich in European heritage, which is predominantly based on mining and pastoral land uses over the past 120 years. This heritage is important to people living in the region as it contributes to the local population’s sense of place. In doing so, the European heritage also serves to attract tourists.

Although the project is proposed to operate in a region rich in European heritage, project activities would not affect any listed or registered European heritage items. There is no mitigation or management required in respect of any buildings or items listed or registered under the Heritage of Western Australia Act 1990.

7.12 VISUAL AMENITY

7.12.1 ASSESSMENT METHODS

The visual characteristics of the project area have been identified using information collected through stakeholder consultation and biophysical/social baseline studies of the area. A baseline photographic survey was conducted July 2009 to document project area viewpoints that represented likely viewing areas for sensitive receptors. A subsequent photographic survey was conducted in November 2010 to assess additional receptor locations introduced as a result of changes to the project configuration.

The Project will be visible from the Yeelirrie to Meekatharra Rd during operation, however post mining and rehabilitation, the landscape will largely be restored to its original profile and will be less obvious to passing traffic.

7.12.2 EXISTING LANDSCAPES

A detailed description of the existing landscape is provided in Section 7 of the PER. Existing visual baseline survey information is provided in Table 7.13 for the seven identified receptor locations.

7.12.3 SOURCES OF POTENTIAL IMPACT

The potential for changes to visual amenity at Yeelirrie is primarily expected during the operational phase of the mine site, and is affected by the location and scale of project infrastructure, the extent of vegetation clearing, the volume and duration of vehicle traffic and the number of people with the potential to view these aspects of the project.

The remote location of the project area, small human population and sporadic placement of homesteads in the wider area surrounding the proposed development suggests the visual impacts would not be significant. Post-closure, no above-ground project facilities would remain, and the mine pit will be completely backfilled and rehabilitated, and therefore the long-term residual impact will be negligible.

Table 7.13: Identification and assessment of potential impacts to visual amenity

Receptor location	Significance (WAPC, 2007)	Approximate distance from infrastructure	Visual conditions incorporating project activities	Predicted visual impact (during LoM)	Residual visual impact (post-closure)
Site 1	Regional Cultural site	10 km SW of pit	The distance from site infrastructure, elevation of the landscape and height of the vegetation would provide a natural screen. Access to this site is limited.	Negligible	Negligible
Site 2	Local Meekatharra-Yeelirrie Road	6 km NW of pit	The distance from site infrastructure, elevation of the landscape and height of the vegetation would provide a natural screen.	Negligible	Negligible
Site 3	Local Meekatharra-Yeelirrie Road	2 km NE of plant	The height of the vegetation would naturally screen the metallurgical plant visible from the Meekatharra–Yeelirrie Road.	Negligible	Negligible
Site 4	Regional Cultural site	2 km E of quarry 8 km NE of plant	Although the field of view is enhanced from the elevated granite breakaway, access to this site is limited. The metallurgical plant and stockpiles would be visible from the breakaway.	Low	Negligible
Site 5	Regional Cultural site	2 km E of quarry 6 km NE of plant	The height of the vegetation would naturally screen the quarry and metallurgical plant from this site. Access to the site is limited and therefore light spill should not be significant to sensitive receptors.	Negligible	Negligible
Site 6	National/state Residential area	22 km SE of pit	The vegetation in the vicinity of the Yeelirrie Homestead would provide a natural screen for the project infrastructure. The site is also a considerable distance from project infrastructure such as the metallurgical plant, which therefore would not be visible from this site.	Negligible	Negligible
Site 7	Regional Cultural site	23 km NE of pit	Although the field of view is enhanced from the elevated granite breakaway, the site is a considerable distance from project infrastructure such as the metallurgical plant, which may be visible. Light spill from the open pit and metallurgical plant would result in a slight glow, however, given the low residential population and the low likelihood of people visiting this area, the light spill would be noticeable only to people travelling through the area.	Negligible	Negligible

7.13 REHABILITATION MONITORING, RESEARCH AND TRIALS

As discussed in Section 2, previous mining has occurred at the Yeelirrie deposit between 1972 and 1980 where WMC undertook several phases of exploration and three trial mining programmes (slots) at Yeelirrie. Ore recovered from this mining was used for detailed metallurgical studies undertaken from 1980 to 1982 at a purpose built pilot plant north of Kalgoorlie (Kalgoorlie Research Plant (KRP)).

A Provisional Closure Plan was prepared for the site in 2001, with closure finalisation works proposed in the amended Rehabilitation Management Plan completed between June and December 2004. A detailed description of the works carried out as part of the closure of the site can be seen within the Yeelirrie Project Close Out Report (WMC, 2004a).

Outback Ecology carried out a rehabilitation monitoring program over a period of five years which resulted in a Rehabilitation and Closure Summary Report (Outback, 2009). Monitoring was carried out using the Ecosystem Function Analysis (EFA) framework to provide data on the success of the rehabilitation closure goal (establishment of a stable and functioning ecosystem). It was proposed that the completion criteria be defined by EFA, therefore successful rehabilitation would be defined as that point where sufficient evidence existed that a functional ecosystem had been established.

Two key areas of the rehabilitation which was carried out are summarised below. The methods followed during this rehabilitation, when compared with the monitoring carried out, can provide valuable reference data for future rehabilitation works and closure planning.

Rehabilitation Earthworks

Rehabilitation earthworks were carried out by Cape Crushing and Earthmoving Contractors Pty Ltd in accordance with the scope of work developed by WMC (WMC, 2003). Key earthworks relevant to future closure planning included:

- Backfilling of mining slots with material borrowed from stockpiles (clean & mineralised waste)
- Grading back and levelling of sides on dewatering channels
- Ripping and seeding of surfaces

Contour ripping was carried out to an approximate depth of 50 – 70 cm over the majority of the rehabilitation areas. This was designed to allow water and nutrients to infiltrate the soil profile and assist with the penetration of revegetation plant roots into the soil. Exposed calcrete outcrops were avoided during the ripping process.

Revegetation Planning

The strategy for rehabilitation of the infrastructure areas was to incorporate Land Systems criteria, including species selection, into final landform design. Three terrain units were identified and mapped; designated as Calcrete Platform (Unit 1), Alluvial Plains (Unit 3) and Drainage Foci (Unit 6), with the plant species existing within each unit identified. Following this, seed was collected (predominately from the immediately surrounding areas) and broadcast onto the rehabilitated areas in December of 2004. The seed mixes intended for use in the various rehabilitation areas which existed within mapped unit are provided in WMC’s Seed Collection and Revegetation SOW (2004b).

The closure summary report concludes that ‘rehabilitation has developed as anticipated’ but goes on to say that below average rainfall appears to have limited the establishment of vegetation within most of the areas undergoing rehabilitation. Monitoring indices obtained from analogue areas for the purposes of direct comparison were generally higher than those recorded within the rehabilitated areas, ‘primarily due to the presence of cryptogams stabilising the soil, and vegetation levels and litter cover positively influencing infiltration and nutrient cycling indices’. Despite these differences the levels obtained were considered adequate given the young age of the rehabilitation.

7.13.1 KEY IMPLICATION FOR CLOSURE

The main implication that previous rehabilitation and monitoring works conducted at the Yeelirrie site have for future closure planning are the large effect variable climate is likely to have on rehabilitation establishment. In particular, variation in climate is likely to have a large impact on early rehabilitation monitoring data and the ability to confidently assess the relative success of rehabilitation procedures. This variability in climate can be negated by the long life of mine and planned progressive rehabilitation, such that with careful monitoring of rehabilitation works completed early in the project life span, the influence of reduced rainfall or other climatic factors can be determined. This will then allow final closure monitoring to factor in variable climate and still provide confidence that rehabilitation is progressing toward end closure goals, or alternatively provide timely data should the reverse be occurring.

8 IDENTIFICATION AND MANAGEMENT OF CLOSURE ISSUES

Following the collection of closure data and the identification of key implications for closure presented in Section 7, identified closure issues were grouped into three domains with three overarching closure principles. The process and methodology used to identify principal closure issues follows the Leading Practice Sustainable Development in Mining handbooks published by the Department of Industry, Tourism and Resources as related to mine closure (DITR, 2006a) and mine rehabilitation (DITR, 2006b). Each closure domain was analysed in respect to the closure data as outlined in Section 7, with the management strategies for each issue being a direct outcome of the domain specific constraints (data-based) and leading practice in the industry (concept-based).

8.1 SAFETY

As there will be no ‘built up’ landforms, safety in the post mine environment will principally revolve around potential radiation exposure to post operational Cameco employees (e.g. environmental monitoring staff), Yeelirrie Pastoral Station employees and members of the public. As discussed in Section 7.10, background levels of radiation which occur naturally in the area above the orebody are elevated above normal or average background levels, with gamma radiation levels up to 6.3 uSv/h and radon gas levels from 10-64 Bq/m^3 (averaging 33 Bq/m^3 across 50 monitoring locations). In comparison average background levels across Australia are for gamma radiation are <0.2 uSv/h and typical global concentrations of radon gas are between 1-100 Bq/m^3.

As the uranium ore is currently outcropping in certain areas and all mine waste (both clean and mineralised waste) and process tailings will be placed back in the mine void and capped beneath an inert layer of soil material > 2 m thick (Section 9) the amount of radioactive material near the land surface is not expected to be significantly increased by mining activity and will most likely be decreased. Therefore ambient radiation doses to human receptors will be similar to, or less than, the pre-mine environment and do not pose a significant risk to post mine safety.

8.2 STABILITY

8.2.1 GEOTECHNICAL STABILITY

The backfilled pit and the in pit TSF’s will require management surrounding the manner of backfilling of the mine pit and the method of construction of the TSF cover to avoid slumping and / or sinkhole development from occurring over the backfilled surface or the TSF. These issues may arise from incomplete compaction or consolidation of either the backfilled subsurface materials or the tailings materials. This can lead to the development of zones of higher permeability, resulting in bypass flow and preferential transport of finer sediment to deeper parts of the profile, and thus leading to sinkhole development. In addition, uneven wetting of the profile over the backfilled pit area may result from uneven material density, and can in turn lead to slumping if the pockets of wetter material are too heavy to be supported by the materials beneath. In either case, an unstable final land surface can result

To avoid slumping and sinkhole development from occurring over the backfilled mine pit, all materials placed back into the pit voids will be compacted to a suitable density as it is replaced. Appropriate lift sizes and compaction densities will be determined from the results of geotechnical testing of the material prior to project commencement. A backfilling management document will be developed to ensure that when replacing the materials subsurface voids or low-density zones are not formed which can lead to stability issues.

The TSF materials will be allowed sufficient time to dry and consolidate prior to the commencement of any rehabilitation activities (i.e. the placement of cover materials). Geotechnical testing of tailings material properties and modelling of consolidation rates has been completed, and this information will be used to guide TSF operation and rehabilitation planning.

8.2.2 EROSION

As the post-mine soil profiles over both the In-Pit TSF and Backfilled Mine Pit areas will consist of backfilled material, there may be an increased risk of surficial instability, resulting in erosion rates that exceed natural background rates. Loss of backfilled soil material has potential follow-on implications for rehabilitation performance, the extent of which depends on the rate of soil loss, particularly during the initial phase of vegetation reestablishment, shortly after mining has ceased. Deposition of eroded sediment within the surrounding environment may also have implications for ecosystem health in otherwise undisturbed areas, and this is discussed further in Section 8.3.2. If excessive erosion is experienced from the rehabilitated TSF areas, this also may result in the exposure of the underlying tailings material.

Given the proposed backfill design and the natural hydrological setting of the project area in the base of valley (see Section 7.5), several distinct types of erosion are possible, including:

- Direct rainfall-induced erosion
- Rainfall-runoff along the backfilled surface (i.e. rill or gully erosion)
- Flood flows around the sides of the backfill (the backfill will be slightly raised above the surrounding topography)
- Extreme flood flows over the top of the backfilled soil profile

These types of erosion will be managed primarily by design and construction of a final landform that will be deliberately shaped to limit erosion potential, and through careful materials management (i.e. selection of erosion-resistant cover materials).

The post-mine landform shape will be consistent with the pre-existing landform shape, as described in Section 7.4 (see also Section 9.9 of the PER). The backfilled mine pit and TSF areas will be built up to a height of approximately 2-3 m above the surrounding topography, and will thus roughly mimic the shape and down-valley direction of the calcrete ridge that forms the central portion of the valley in the pre-mine environment. Surface water flow modelling (URS, 2015) indicates that the proposed post-mine landform will allow the surface water flow regime to remain in-tact, with two primary down-valley flow channels extending along either side of the deposit. This will be achieved by utilising the natural valley topography on the south side of the deposit, and by cutting an artificial channel on the north side of the deposit to mimic the pre-mine valley geometry (URS, 2015).

Flood modelling predicts that, given this configuration, large floods in the vicinity of the deposit are likely to result in greater flood depths and flow velocities in some locations as compared to the pre-mine environment. The greatest increases are likely to occur in the northern flow channel, owing to the slightly restricted shape of this channel as compared to the pre-mine landform. However, even within this area, the overall change to flood flow velocity is relatively modest (increase of 0.2 – 0.4 m/s for storm events up to the 1:1,000-yr ARI event). Given the relatively low predicted flow velocities (generally less than 0.8 m/s at all locations) fluvial erosion potential is expected to remain similar to pre-mine conditions.

Constructed landform slopes will be very gradual, at less than 0.5° in all directions, thus limiting rainfall-runoff erosion potential. The native surficial loam, which constitutes the primary soil material to be used for rehabilitation of the backfilled profiles, has been demonstrated to be reasonably erosion resistant (Section 7.4) (SWC, 2015b), with predicted 10,000-year soil losses of <0.5 m over approximately 80-85% of the former TSF area. Some potential for gullying of (up to 1.5 m depth) has been predicted for the remaining 15-20% of the area, and thus ongoing investigations are being conducted to determine ways to further protect the landform from erosion in these areas.

Soil materials will be stripped and stockpiled prior to mining to ensure sufficient quantity is available for rehabilitation.

8.3 POLLUTION

8.3.1 GEOCHEMISTRY

The mine waste materials (both clean and mineralised waste) generated during mining will be placed back into the mine void as backfill material in those areas of the mine pit not utilised as in-pit TSF. The materials scheduled to be backfilled upon mine closure will be stored in stockpiles during the majority of the operational phase of the project. As discussed in Section 7.3, leaching trials were conducted on these materials to determine likely solute release levels (SRK, 2011) from the stockpile materials. When the results of solubility leach testing were compared to average groundwater quality monitoring results the concentrations of most solutes were lower within the leaching tests. This suggests that solute release is occurring mostly from salinity that would have been present within the pore water of the samples.

As the potential for acid generation within the stockpiled materials is considered minimal (Section 7.3) the changes in redox conditions will not accelerate solute release above that already modelled. Therefore the modelling results carried out upon the stockpiled materials can be applied to the backfilled mine pit domain and used to illustrate that solute release levels from the clean and mineralised waste materials to be stored within the backfilled pit are unlikely to cause significant changes in groundwater quality in the recovering aquifer.

As outlined in Section 7.6.12, some leaching of contaminants of concern (COC) from the TSF cells into the groundwater system may occur. Depending on the concentration of COCs in the leachate, and the extent of the resulting plume, there is potential for impact on local and downstream receptors, including:

- local and downstream subterranean ecosystems
- downstream GDE ecosystems
- downstream water users
- local and downstream future beneficial uses

However, as outlined in Section 7.6.5 and 7.6.6, there are few existing groundwater users in the region, and the potentially impacted aquifers (i.e. aquifers beneath the valley floor) are typically already saline to hypersaline, thus limiting the potential for beneficial uses. Further, dissolved uranium is already present in all of the hydrostratigraphic units down to the base of the palaeochannel. The concentration of uranium close to the deposit averages 0.29 mg/L (± 0.32 mg/L) and in the palaeochannel sediments it is 0.74 mg/L (± 0.69 mg/L). The majority of groundwater in the valley floor setting is therefore already unsuitable for stock water use (ANZECC guideline value is 0.2 mg/L), which constitutes the most likely future water use in the area.

Despite this, the TSF cover system has been designed specifically to limit the infiltration of water into the tailings cells, and thus is designed to limit subsequent leaching of COCs. As outlined in Section 9.2.3, the cover system will consist of at least a 2 m surface covering of surficial loam soil, overlaying a 1 m capillary break constructed from clean and mineralised waste calcrete. It has been designed such that the upper soil profile has approximately 400 mm of water holding capacity. HYDRUS modelling indicates that this is sufficient to limit recharge through the TSF cell to an average of 1.2 mm per year (see Section 7.4.5). Contaminant transport modelling of the rehabilitated TSF showed that lower recharge rates help to limit the extent of COC plumes, and also to limit the concentration of COCs in groundwater (Cameco, 2015a).

Residual impact is therefore limited primarily to the local area. Subterranean ecosystems are possibly the most sensitive receptor, although the potential impact on stygofauna from small-scale changes in geochemistry is still relatively poorly understood.

Groundwater and tailings chemistry will be monitored throughout LOM to identify any further issues and to refine the contaminant transport estimates, if required.

8.3.2 HYDROLOGY

As discussed in Section 8.2.2, there is some potential for increased soil erosion rates in the post-closure environment, and this has the potential to increase the volume of sediment transported within the hydrological environment. This could lead to modification or contamination of the surrounding environment by:

- Deposition of sediment in sensitive environments
- Exposure of tailings material through excessive erosion, and subsequent entrainment of tailings material in surface water flows

As discussed further in Section 8.2.2, erosion will be managed primarily by design and construction of a final landform that will be deliberately shaped to limit erosion potential, and through careful materials management (i.e. selection of erosion-resistant cover materials). These management measures are expected to be sufficient to limit excessive increases in sediment transport through the hydrological system, and are expected to limit erosion of the post-mine landform such that the tailings material will not be released into the surrounding environment.

8.4 SUSTAINABILITY

8.4.1 HYDROGEOLOGY

The following mining-related activities have been identified that will modify the hydrogeological regime during the LoM, and that may have lasting impacts beyond site closure:

- Mine pit dewatering, which lowers the water table by up to 8 m
- Water extraction from the identified bore fields, which lowers the water table by up to 6 m, and interacts with the drawdown cone resulting from the pit dewatering
- Mining of the ore-hosting calcrete material (which has a high hydraulic conductivity), and progressive backfilling with tailings material (which has a low hydraulic conductivity)

Mine pit dewatering and bore field extraction were assessed as part of a recent Groundwater Study (Cameco, 2015a). As described in more detail in Section 7.6.11 (see also Section 9.5 of the PER), the groundwater model predicted that aquifer drawdown would reach its maximum extent in Year 22 of the project, and that groundwater levels would start to recover to background levels shortly after site closure. It was predicted that the majority of recovery would be completed within 50 years after the cessation of pumping. Complete recovery was predicted at 100 years within the vicinity of the mine pit, and 200 years in the vicinity of the bore fields.

As previously discussed in Section 7.6.11, a large volume of calcrete material (which is highly porous and conductive, K ≈ 500 m/d) will be removed from the mining zone, and replaced with tailings cells (which have a very low conductivity, K = 10-4 m/d). It might be expected that down-gradient groundwater flows would "back up" upstream of the TSF cells. However, the geologic cross-sections indicate that reasonably contiguous "high" transmissivity sands exist directly to the south of the pit area; at their narrowest, they are approximately 2 km wide, and extend approximately 20 m below the water table. This sandy alluvium therefore represent 8-10 times the cross-sectional area of the calcrete aquifer that is to be removed from the mining area, and it is therefore expected that this strata has sufficient capacity to avoid any "backing up" of water upstream of the TSF cells. This is supported by the hydrological model results, which showed no permanent change in the groundwater level in the vicinity of the backfilled pit or TSF.

Based on the results of the groundwater studies, no active management is proposed. Post-closure monitoring activities are discussed in Section 10.

8.4.2 REHABILITATION

The two main issues identified during the risk analysis in relation to rehabilitation of the two closure domains are:

- Underperforming revegetation growth and establishment not meeting completion criteria goals
- Upper surface of the backfilled profile not constructed according to developed design

The upper surface of the backfilled mine pit and the TSF cover material have been carefully designed to maximise surface stability and minimise excessive water infiltration below the upper profile. Revegetation candidate species will be selected to form a resilient, functional ecosystem whose growth requirements are able to be met by the surficial profile. Given that the revegetation species selection will include the criteria that reconstructed soil profiles are able to maintain vegetation requirements (e.g. plant available water, nutrient stores etc.), it is expected that with the appropriate climatic conditions successful revegetation establishment and growth will occur, thereby meeting the specified completion criteria.

To ensure that the construction of the upper surface of the mine pit backfill and the cover system for the in-pit TSF cells occur according to the design, all earthmoving operators working on rehabilitation will be effectively trained in the specifics of the design to ensure that all materials are handled and utilised correctly. Procedures will be established to require shift supervisors to monitor and report on the construction progress to the site environmental officer on a weekly basis. The site environmental officer will also undertake periodic checks on the performance of the construction to provide confidence in compliance. A ground control management plan, similar to that used for the construction of the open pit, will be prepared prior to construction to provide sufficient direction for all personnel working in rehabilitation activities.

8.5 GAP ANALYSIS

An analysis of the key implications for closure (Section 7) and the identified closure issues has yielded a number of knowledge gaps that are required to be filled to ensure that the appropriate management options can be developed.

The identified knowledge gaps are listed in Table 8.3. Investigations will be developed and carried out which are designed to fill these gaps in order to accurately assess the environmental risks associated with the proposed mining and processing activities and the ability to re-establish safe, stable, non-polluting and self-sustaining post-mine domains upon closure.

Table 8.1: Identification of Closure Issues

Overarching Closure Principle		Safety	Stability		Non-Polluting		Sustainability	
Closure Issue			Geotechnical Stability	Erosion	Geochemistry	Hydrology	Hydrogeology	Rehabilitation
Domains	Backfilled Mine Pit	Gamma radiation from backfilled material exceeds background levels Radon exhalation from backfilled material exceeds background levels / human health criteria	Unconsolidated backfill material slumps resulting in unstable and undulating land surface	Backfilled soil profile results in restricted surface water channel, and causes increased fluvial erosion of the valley floor and sediment transport. Rainfall-induced erosion of the backfilled soil profile results in an unstable surface and poor rehabilitation performance. Flood flows over the backfilled soil profile cause excessive soil loss and poor rehabilitation performance.	Possible development of neutral metaliferous drainage / excessive solute transport from backfilled material into regional aquifer	Backfilled pit voids may affect water quality through erosion of backfill material and sedimentation of surrounding environment.	Residual groundwater table drawdown persists at closure, thus impacting on subterranean or GDE ecosystem functioning.	Re-establishment of vegetation and ecosystem function not meeting closure goals. Surface cover not constructed to design Spread of weed species inhibiting local species re-establishment.
	In-Pit Tailings Storage Facility (TSF)	Gamma radiation levels on surface from process tailings exceeds background levels Radon exhalation from process tailings exceeds normal background levels / human health criteria	Unconsolidated tailings material slumps resulting in unstable and undulating land surface.	Backfilled soil profile results in restricted surface water channel, and causes increased fluvial erosion of the valley floor and sediment transport. Rainfall-induced erosion of the backfilled soil profile results in an unstable surface and poor rehabilitation performance. Flood flows over the backfilled soil profile cause excessive soil loss and poor rehabilitation performance. Erosion of the backfilled soil profiles result in exposure of the tailings material	Leaching of contaminants of concern (COC) from the TSF cells into the groundwater system, thus impacting on downstream subterranean or GDE ecosystem functioning. Leaching of COCs into the groundwater system, thus impacting on downstream water users Leaching of COCs into the groundwater system, resulting in potential loss of value for future beneficial uses	Erosion of the backfilled soil profile and sedimentation of the surrounding environment. Exposure of tailings material through excessive erosion of the backfilled soil profile leads to contamination of the surrounding environment. Extreme flood events (i.e. >1:100-yr ARI) lead to flooding over the cover system, and subsequent increase in infiltration into the TSF cells	Residual groundwater table drawdown persists at closure, thus impacting on subterranean or GDE ecosystem functioning. Low-permeability tailings cells cause “blockage” of down-gradient groundwater flow, resulting in permanent changes to local groundwater levels.	Re-establishment of vegetation and ecosystem function not meeting closure goals. Tailings cover not constructed to design Spread of weed species inhibiting local species re-establishment.

Table 8.2: Management of Closure Issues

Overarching Closure Principle		Safety	Stability		Non-Polluting		Sustainability	
Closure Issue		“	Geotechnical Stability	Erosion	Geochemistry	Hydrology	Hydrogeology	Rehabilitation
Domains	Backfilled Mine Pit	Post mine radiation assessment has shown that ambient radiation doses to human receptors will be similar to the pre-mine environment Ongoing monitoring of radiation throughout LOM and closure activities	Backfilled pit is constructed to stable design as determined by geotechnical modelling.	Backfill mimics the shape of the pre-mine calcrete ridge, allowing surface flows to pass relatively unimpeded. Backfill is raised above surrounding topography to limit interaction with down-valley surface water flows. Landform slope angles of <0.5° Use erosion-resistant soils for rehabilitation.	Bottle leach testing confirms potential for leachate run-off from stockpiled waste materials is low Sampling of waste rock material and monitoring of surface and groundwater.	Backfill mimics the shape of the pre-mine calcrete ridge, allowing surface flows to pass relatively unimpeded. Backfill is raised above surrounding topography to limit interaction with down-valley surface water flows. Landform slope angles of <0.5° Use erosion-resistant soils for rehabilitation.	Modelling of post-mine environment showed full recovery of groundwater levels in the post-closure environment – No additional management proposed	Progressive rehabilitation program designed to detect problems with approach prior to mine closure Development of construction management system to ensure correct design followed Development of weed management program
	In-Pit Tailings Storage Facility (TSF)	Post mine radiation assessment has shown that ambient radiation doses to human receptors will be similar to the pre-mine environment Ongoing monitoring of radiation throughout LOM and closure activities	In-pit TSF pit is constructed to stable design as determined by geotechnical modelling. Management of tailings deposition determined by geotechnical testing and trials TSF cover system is constructed to stable design as determined by geotechnical modelling.	Backfill mimics the shape of the pre-mine calcrete ridge, allowing surface flows to pass relatively unimpeded. Backfill is raised above surrounding topography to limit interaction with down-valley surface water flows. Landform slope angles of <0.5° Use erosion-resistant soils for rehabilitation.	Construction of cover system specifically designed to minimise infiltration and leaching Sampling of tailings material and monitoring of surface and groundwater. Ongoing groundwater monitoring is designed to detect potential groundwater quality issues throughout LOM.	Backfill mimics the shape of the pre-mine calcrete ridge, allowing surface flows to pass relatively unimpeded. Backfill is raised above surrounding topography to limit interaction with down-valley surface water flows. Landform slope angles of <0.5° Use erosion-resistant soils for rehabilitation.	Modelling of post-mine environment showed full recovery of groundwater levels in the post-closure environment – No additional management proposed	Progressive rehabilitation program designed to detect problems with approach prior to mine closure Development of construction management system to ensure correct design followed Development of weed management program

Table 8.3: Gap Analysis

Overarching Closure Principle		Safety	Stability		Non-Polluting		Sustainability	
Closure Issue		“	Geotechnical Stability	Erosion	Geochemistry	Hydrology	Hydrogeology	Rehabilitation
Domains	Backfilled Mine Pit	None identified	Behaviour of backfilled waste after deposition, likely consolidation times	Investigate alternative surface armouring materials to enhance surface stability of cover designs	None identified	None identified	Effects of short-term residual groundwater table drawdown on subterranean fauna	None identified
	In-Pit Tailings Storage Facility (TSF)	None identified	None identified	Investigate alternative surface armouring materials to enhance surface stability of cover designs	None identified	Infiltration of potential surface flood-flows through cover system (i.e. recharge rate to TSF cells)	Effects of short-term residual groundwater table drawdown on subterranean fauna	None identified

9 CLOSURE IMPLEMENTATION

9.1 OVERVIEW

Closure implementation will occur progressively throughout the LOM. Closure implementation is integrated into the LOM Planning, at every stage of the operation, to ensure that material, machinery and personnel resources are available to complete the rehabilitation and closure tasks in accordance with the stakeholder agreed end land use objectives and criteria. Table 9.1 includes an overview of the key implementation steps required at various stages throughout the LOM, and Sections 9.2.1-9.2.6 describe each Closure Aspect in more detail.

Progressive rehabilitation is favoured by Cameco, and wherever practicable, timely rehabilitation of post-mine landforms will occur following the cessation of mining activity in the area. This is considered an important economic-driver, as open and non-rehabilitated areas represent a liability to the operation.

Table 9.1: Overview of Closure Implementation

Rehabilitation / Closure Aspect	Implementation
Baseline data collection	• Baseline studies, completed and discussed in Section 7 • Ongoing monitoring throughout LOM (see Section 9 of the PER)
Material handling and utilisation	• Stripping and stockpiling of identified surficial soil materials for later use in rehabilitation. To be completed prior to commencement of mining • Temporary stockpiling of all waste material as it is removed from the mining area. To be stockpiled for later backfilling into the open pit areas • Process tailings will be backfilled into the designated In-Pit TSF cells throughout LOM, according to the mining schedule in Figure 2.3.
Design and construction of landforms	• TSF cover system to consist of 1 m of capillary break material and at least 2 m of growth medium (Figure 9.1) • Backfilled Pit areas to be covered with at least 1 m of growth medium • TSF and Backfilled Pit areas to be shaped into one contiguous landform, slightly raised and comparable to original profile
Identification and management of site contamination	• Areas where the potential for contamination is identified will be assessed and managed in accordance with the DER and *Contaminated Sites Act 2003* requirements

Rehabilitation / Closure Aspect	Implementation
Rehabilitation of landforms	• TSF cells will be progressively covered and rehabilitated according to the mining schedule outlined in Figure 2.3, starting in Year 11 of the operation. • Remaining open pit areas to be backfilled with mine waste in Years 19-22 of the operation. • Backfilled Pit and TSF areas to be completed according to the cover system design (Figure 9.1), as soon as practicable after backfilling. • Land surfaces to be shallow ripped and seeded with identified rehabilitation seed mixtures
Decommissioning & removal of project infrastructure	• At the completion of operations, support infrastructure will be progressively removed in line with remaining closure requirements • Potentially radioactive materials and/or equipment will be surveyed and, if found to be above guideline levels, buried within the pit in line with tailings and remaining low grade stockpiles. • All disturbed areas to be shallow ripped and seeded with identified rehabilitation seed mixtures
Monitoring of rehabilitation performance	• Monitoring of rehabilitation performance is outlined in Section 10

9.2 IMPLEMENTATION OF CLOSURE ASPECTS

9.2.1 BASELINE DATA COLLECTION

Collection of base line data begins at the start of project inception with flora and fauna clearing surveys and continues through all stages of the project. Knowledge of baseline conditions is critical for a number of planning purposes including closure planning. The product of the ongoing collection of baseline data at this stage in the project life cycle are presented in detail within the PER, with discussion of baseline data that is relevant to closure planning presented within Section 7 of this document.

9.2.2 MATERIAL HANDLING AND UTILISATION

In order to ensure that the necessary materials are available for site closure, it is critical that all such materials are identified and managed correctly throughout LOM. Further, careful materials management will be required to ensure that the mine pits are able to be backfilled, whilst maintaining continued productivity of the mine site.

The proposed mine schedule (Figure 2.3) includes a construction, operation, and decommissioning and closure timeline of 22 years. The schematic drawing outlining the progression of the mining process is provided in Figure 9.2. The deposit will be mined in 15 Mining Blocks, with the mining phase projected to take 15 years to complete. The deposit will be dewatered in 8 Dewatering Blocks, designed to ensure that dewatering is one year ahead of the mining face. Prior to mining of each block, the upper 1-2 m of the soil profile (i.e. the surficial loam) will be stripped and stockpile, as it represents the most beneficial material for rehabilitation of the land surfaces. Likewise, the calcrete will be removed to just above the water table within each dewatering block, and stockpiled as capillary break material.

As the mining front progresses, ore-bearing material will be stockpiled to await processing, and waste material (consisting of clay-quartz, calcrete, and clay/loam) should be stockpiled separately for use in the various rehabilitation and construction needs relevant to the Project. Process tailings material will begin to be deposited in the mined-out blocks in Year 4 of the project. Tailings from mining blocks MB#1 to MB#3 will be deposited in Pond#1, consisting of five cells with an average size of 309,000 m^2. The tailings from mining blocks MB#4 to MB#15 will be placed in Pond#2 which consists of five cells with an average size of 339,500 m^2. Pond#1 will be operated for seven years and Pond#2 for eight years.

Placement of a cover of the In-Pit TSF cells, utilising the stockpiled calcrete and surficial loam soil, will start after filling of Pond#1 has been completed, and tailings have consolidated (Year 11), followed shortly by rehabilitation of the finished land surface. Cover system construction and rehabilitation of Pond#2 will begin after the end of milling, in Year 19.

Stockpiled mine wastes will be backfilled into Mining Blocks 8-15, starting in Year 19. The Backfilled Mine Pits will likely be the last areas to be rehabilitated. The remaining stockpiled surficial loam and calcrete material which has not been used in developing the TSF cover system will be used to rehabilitate the land surface in these areas.

9.2.3 DESIGN OF LANDFORMS

The TSF cover system has been designed specifically to:

- limit infiltration into the tailings cells
- limit the upward movement of water and solutes from the tailings into the soil profile
- be resistant to excessive erosion
- provide adequate growth medium for the establishment of rehabilitation species.

The proposed TSF cover system design is shown in Figure 9.1. It consists of a 1 metre-thick layer of clean and mineralised waste calcrete, placed directly above the consolidated tailings material to act as a capillary break. This limits the upward movement of water and solutes from the tailings into the growth medium.

The capillary break will in turn be overlain by at least 2 m of the stockpiled surficial loam soil. This native soil will act as a growth medium for rehabilitation species and, due to its relatively large water holding capacity, will limit infiltration through the profile.

The cover system will result in a slightly mounded final landform shape, that will be water shedding, but also resistant to erosion. This design has been carefully designed to take advantage of the materials available for use in rehabilitation whilst ensuring that the overall closure goals are met. The design of the final landform is discussed further in Section 9.12 of the PER.

9.2.4 IDENTIFICATION AND MANAGEMENT OF SITE CONTAMINATION

Site contamination as a result of activities during mine site operation has the potential to compromise environmental values and result in non-compliance against relevant closure criteria. In areas where the potential for soil contamination is identified (e.g. areas used for storage of process chemicals, explosives, fuels and/or lubricants) soil samples (and potentially groundwater samples) will be taken and analysed. Any potentially contaminated soils identified by this assessment will be managed in accordance with the Department of Environmental Regulation and *Contaminated Sites Act 2003* requirements. Further sampling and analysis will then be undertaken to confirm the performance of the contaminated soil management measures implemented.

9.2.5 REHABILITATION OF LANDFORMS

Progressive rehabilitation is favoured by Cameco, and wherever practicable, timely rehabilitation of post-mine landforms will occur following the cessation of mining activity in the area. The proposed mining schedule, presented in Figure 2.3, includes cover placement, and commencement of revegetation starting after completion of the first TSF cell, in Year 11 of the project. All remaining open pit areas that are not converted to TSF cells will be backfilled with mine waste in Years 19-22 of the operation.

The In-Pit TSF cells will be completed according to the cover system design discussed in Section 9.2.3 (Figure 9.1), as soon as practicable after tailings deposition and settling has been allowed to finalise. Backfilled Mine Pits will be covered with an approximately 1 metre-thick layer of loam which will act as a growth medium for revegetation and act to restore hydrological processed which were in place prior to project development.

All finished land surfaces will be shallow ripped to promote stability and revegetation establishment and seeded with identified rehabilitation seed mixtures of local provenance.

9.2.6 DECOMMISSIONING & REMOVAL OF PROJECT INFRASTRUCTURE

An assessment of radiation will be conducted for infrastructure involved processing such as the metallurgical plant and process water evaporation pond. All material deemed to exceed relevant radiation guidelines will be placed within the mine pit and covered with inert overburden and topsoil in the same fashion as tailings and remaining low grade stockpiles.

Decommissioning of fixed site assets will be carried out after the assessment of radiation by the specialist mining contractor who will provide the majority of the infrastructure and equipment needed to conduct mining operations. The specialist mining contractor will be required as part of their contract to remove all its assets from site at the completion of the contract.

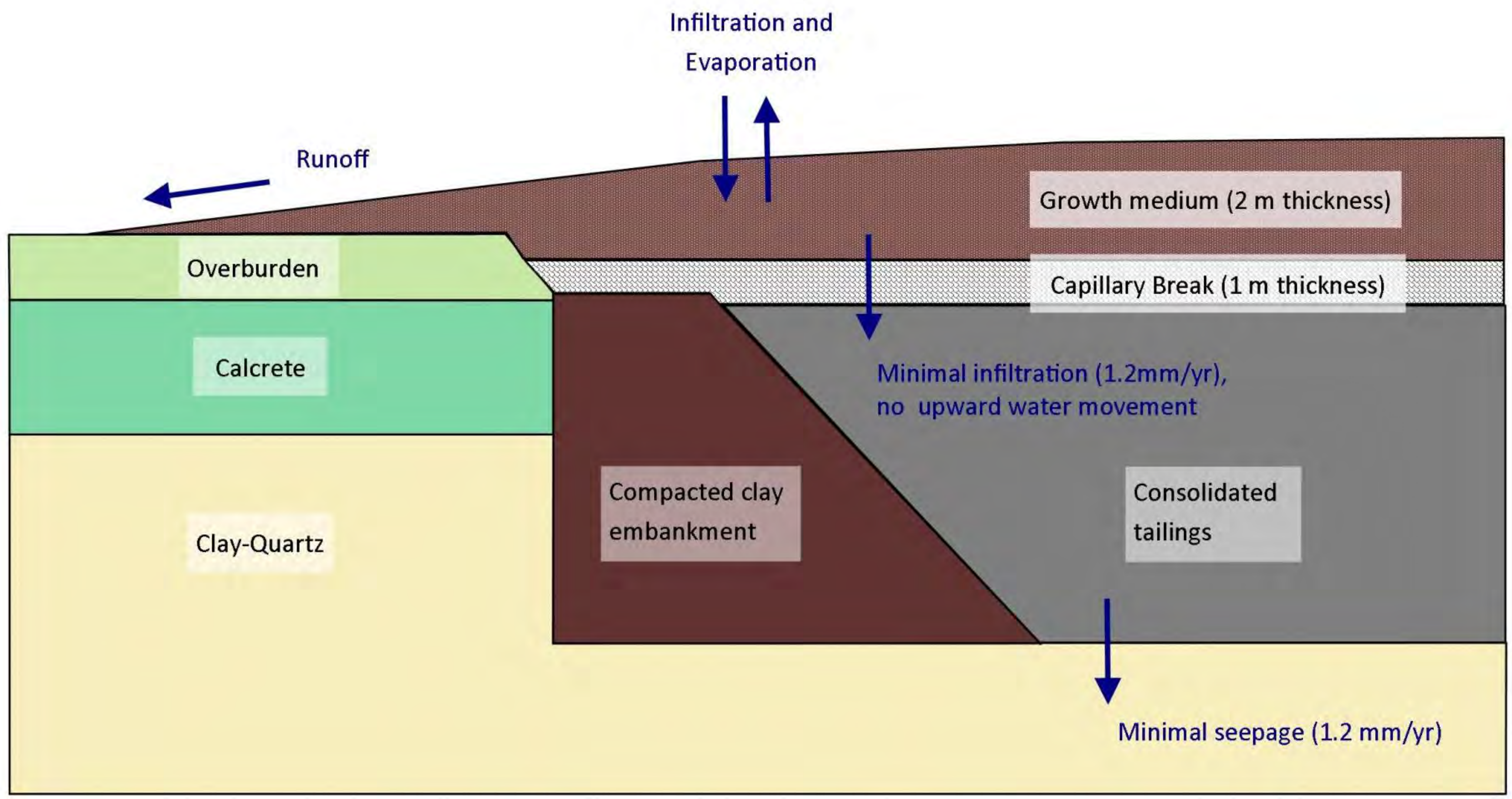
Upon conclusion of operational activities the infrastructure associated with dewatering and water supply will be removed, with all water bores capped in accordance with the requirements of the relevant government administering authority. All surface water diversion bunds and sediment traps will be removed, with the land contoured to as close to pre-mine level as practicable.

Cameco’s office buildings and minor equipment will be removed from site.

Haul roads that have not been progressively rehabilitated during the mine life will be re-profiled (including removal of portions of haul road embankment where necessary) to blend in with surrounding topography. Where necessary, road surfaces will be re-profiled to allow free drainage and minimise interference with surface flows.

9.2.7 MONITORING OF REHABILITATION PERFORMANCE

The monitoring of rehabilitation performance has already begun with data collected from trial mining and rehabilitation areas at Yeelirrie (Section 7.13). As discussed in Section 10, monitoring of baseline conditions and areas of the environment such as groundwater and air quality will continue throughout the LOM and into closure. Rehabilitation monitoring will be conducted as progressive rehabilitation proceeds, with the results feeding into rehabilitation planning in an iterative process designed to refine and improve rehabilitation procedures and outcomes.



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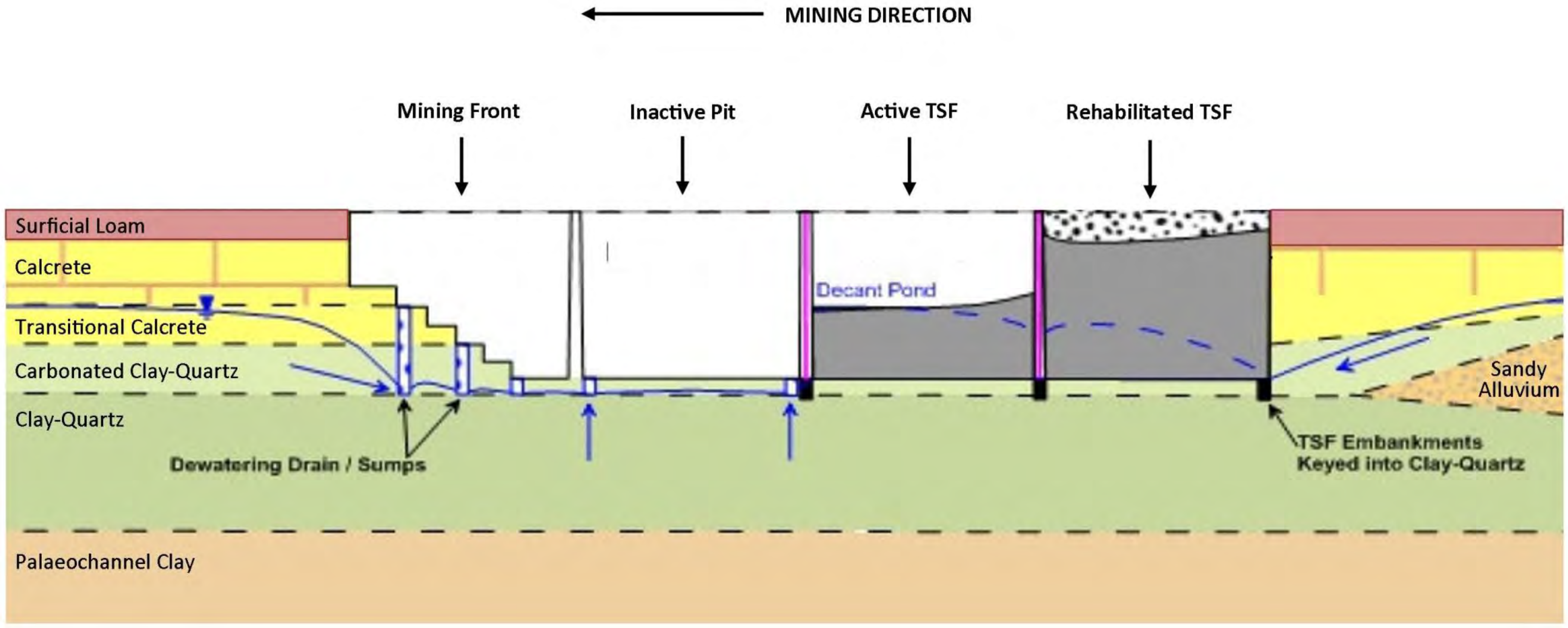
Yeelirrie Uranium Project MINE CLOSURE PLAN

Figure 9.1: TSF cover system conceptual design

Cameco



Error! Reference source not found.	Figure 9.2: Planned progression of the mining front and progressive rehabilitation	Cameco
Yeelirrie Uranium Project MINE CLOSURE PLAN		

9.3 ADAPTIVE MANAGEMENT

Adaptive management or the iterative development of rehabilitation and closure procedures will be used throughout the LOM. A part of adaptive management is the implementation of contingency measures where ongoing rehabilitation monitoring shows that management objectives and closure criteria are not being achieved, or if monitoring techniques cannot accurately define if management objectives and closure criteria are being achieved. The provisional closure criteria will contain qualitative management triggers which will be revised after the first and ongoing monitoring rounds to allow the continual evolution of management strategy and ensure objectivity in assessing monitoring data.

Expert opinion will be sought if and when required, to guide contingency measures which may include further monitoring work to better understand influences causing changes in the environment. By understanding why certain management strategies or monitoring does not work, specialist advice can be used to modify and improve these programs, so that rehabilitation procedures and closure planning are continually improving with respect to achieving closure goals.

9.4 UNPLANNED OR UNEXPECTED CLOSURE

Cameco understands that given the long LOM of the project, future changes in the political, economic, organisational or environmental *status quo* may result in unplanned or unexpected permanent closure or suspension of operations under Care and Maintenance. As these events may represent an appreciable environmental risk, the DMP and EPA require that consideration is given in the MCP to addressing and mitigating any potential impacts to the environment, and which may result in an unacceptable liability to the State.

Implementation of effective progressive rehabilitation is the best mechanism to protect against unplanned or unexpected closure or suspension of operations. Through progressive rehabilitation, the area of land left open and not rehabilitated to an acceptable agreed standard is kept to a practicable minimum, reducing the potential liability of the site.

In addition to progressive rehabilitation during operations, planning for unexpected closure or suspension of operations at Yeelirrie will involve the following:

- Construction of safe closure domains that do not represent a risk to humans and animals
- Prevention of potential physical (e.g. erosion, subsidence) and chemical (e.g. metalliferous drainage) pollution pathways from either establishing or accelerating over time
- Develop management systems to prevent unsupervised access to sensitive domains

A critical aspect of the progressive rehabilitation process is the integration of mine closure into the LOM planning at all stages of the project life span. This ensures that those resources required in developing and completing rehabilitation works, in both the short and long-term, are factored into during the operational phase; thus there is an up-to-date register of required rehabilitation and closure provisions. The strength of this process is enhanced through the application of annual cost provisioning for closure, congruent with the closure cost estimating methodology outlined in Section 11. This allows for the current closure cost liability to be readily established, and the present closure obligation costs to be defined in the case of unplanned or unexpected closure or suspension of operations.

10 CLOSURE MONITORING AND MAINTENANCE

10.1 MONITORING PROGRAMME OVERVIEW

Monitoring programmes will be designed to evaluate the performance of rehabilitated mine landforms and to assess whether they have either met the site completion criteria or are showing satisfactory progress towards meeting these criteria. These programmes will be implemented as new areas of the mine are rehabilitated through the progressive rehabilitation methodology and will be refined based on monitoring results and rehabilitation success.

The overarching goals for monitoring systems to be used at the Yeelirrie Project are to provide key stakeholders (both internal and external):

- Clear and robust data on progress towards rehabilitation goals
- integrated information that considers pathways for contaminant, water and energy flows in the wider receiving environment
- definitive boundary conditions for intervention and ‘science-based’ (i.e. quantitative) evidence of appropriate contingency strategies
- definitive end-points for closure

An important component of effective rehabilitation efforts is the use of monitoring and trials to track the progress of rehabilitation and ensure continuous improvement through adaptive management, such that:

- Monitoring procedures are used to assess whether initial establishment has been successful , rehabilitation is developing satisfactorily and is ready for signoff; and
- Trial activities are undertaken where knowledge gaps or deficiencies in rehabilitation progress occur.

Cameco’s adaptive management approach to closure planning will involve regularly assessing rehabilitation performance by taking into consideration results of progressive rehabilitation and previous trials, and refining its management practices to facilitate continuous improvement. Rehabilitation areas and trials will be monitored on a regular basis to assess the success or otherwise of a particular rehabilitation technique, with the results used to further refine the operations rehabilitation programme.

Monitoring events will be undertaken in line with the process outlined within this section, with the outcomes informing rehabilitation strategies, facilitating refinement in completion criteria and directing maintenance and remedial action plans.

10.1.1 REHABILITATION MONITORING METHODOLOGY

Progressive rehabilitation and ongoing performance assessment will be carried out in areas where mining and related operations have been completed and further disturbance is unlikely. Best practice monitoring procedures will be used to assess whether initial establishment has been successful, rehabilitation is developing satisfactorily and is ready for signoff.

Monitoring of all rehabilitated areas will be conducted on an annual basis for a period of three to five years to determine initial establishment, then on a biennial basis to determine trajectory towards stable ecological function/diversity and resilience in accordance with provisional completion criteria (Table 6.1). Areas should be monitored as soon as possible, in the appropriate season, following completion of earthworks, spreading of topsoil and any seeding/planting. Ideally, monitoring should be conducted between April-June each year, where this is not possible due to operation scheduling a second monitoring event during the first year of rehabilitation will be conducted to ensure continuity of results and allow direct comparison of data.

10.1.2 WEED MONITORING

A formal *Weed Management Plan* will be prepared before the commencement of the Project

As outlined in Section 7.7.9, the 11 weed species recorded within the project area are generally non-aggressive species, and require only minimal management. However, the presence of *Acetosa vesicaria* in areas rehabilitated in 2004 is a concern as these areas could potentially act as a weed seed source in future.

Weed management focussed on the control of Ruby Dock is already conducted each year. In the future, including during the Life of Mine, controls will be established. These will include vehicle washdown and inspection procedures to reduce the potential for weed species to be introduced; an annual site survey for weeds, and a targeted spraying program. The inspection and spraying program would continue post-closure.

10.1.3 FAUNA MONITORING OF REHABILITATION AREAS

A *Post-Closure Monitoring Program* will be developed during the Life of Mine and prior to the completion of the first phase of rehabilitation.

Monitoring of fauna activity on rehabilitated areas will be conducted on both a formal and informal basis. Following revegetation, fauna monitoring will be conducted to determine the level of grazing of the rehabilitated areas by feral animals including goats, donkeys, horses and camels as well as livestock animals. Where necessary, animals will be removed from the land to release grazing pressure on rehabilitation.

Colonization of rehabilitated areas can also be used as a measure of the success of the rehabilitation. The presence of insects such as ants and other colonizers would be monitored and recorded as part of the rehabilitation monitoring program.

10.1.4 SURFACE WATER MONITORING

A draft *Surface Water Management Plan* has been prepared and is included in the Surface Water Study report appended to the PER (URS, 2015). The draft Plan will be finalised prior to the commencement of mining.

As outlined in the draft Plan, surface water monitoring will be conducted to ensure that the Project is not having an impact on downstream surface water quality.

10.1.5 GROUNDWATER MONITORING

A draft *Groundwater Management Plan* is included in the Groundwater Study appended to the PER (Cameco, 2015a). The draft Plan will be finalised prior to the commencement of mining.

Groundwater monitoring will be undertaken to confirm groundwater drawdown predictions from the groundwater model, and to measure selected groundwater quality parameters throughout LoM and, as necessary, in the post-closure time period.

10.1.6 RADIATION MONITORING

A draft Radiation Management Plan (RMP) will be developed for the Project which will be provided to the DMP and Radiological Council prior to the commencement of construction activities. The RMP will include details of radiation protection and radioactive waste management specific to the plant and address the requirements of the Western Australian NORM Guidelines (DMP, 2010) and the ARPANSA Mining Code (ARPANSA, 2005). Further detail on the principles that will be applied in the RMP and an outline of the methods to be employed in applying these principles to the Project, including an outline of the radiation control methods and an overview of the proposed monitoring, is provided within the PER (Section 9.6.6).

During the implementation of closure activities after the cessation of operations, the monitoring activities defined by the RMP for both occupational radiation monitoring and environmental radiation monitoring will continue to be implemented as appropriate.

Four radiation monitoring sites have been installed at the Project to provide baseline date on radiation levels. These sites have been selected based on their proximity to sensitive receptors and to provide even coverage around the orebody. The location of the four sites is shown in Figure 10.1 . Each site consists of the following:

- Dust Deposition Gauge (set up to AS/NZS 3580.10.1:2003) - to be analysed annually for Total Solids, Insoluble Solids, Soluble Matter, Dust Weight, Gamma Spec and Mass Spec (10-12 metals).
- Environmental TLD badge - installed to measure long term average gamma doses over time.
- Radtrak - alpha-track radon gas detector (installed in protective canister to reduce exposure to heat) - installed to measure long term average radon concentration over time.

The dust deposition bottles, TLD badges and Radtrak’s will be collected and replaced on a monthly and quarterly basis (depending upon the requirements). TLD badges and Radtrak’s will be sent off for analysis on a quarterly basis.

The data collected from these sites will be used along with data from activity specific radiation monitoring and relevant guideline values to develop radiation Closure Criteria for the Project. Monitoring of the baseline sites, along with surface water and groundwater monitoring would continue for a period of time post-closure until the agreed Completion Criteria had been achieved to the satisfaction of regulators.

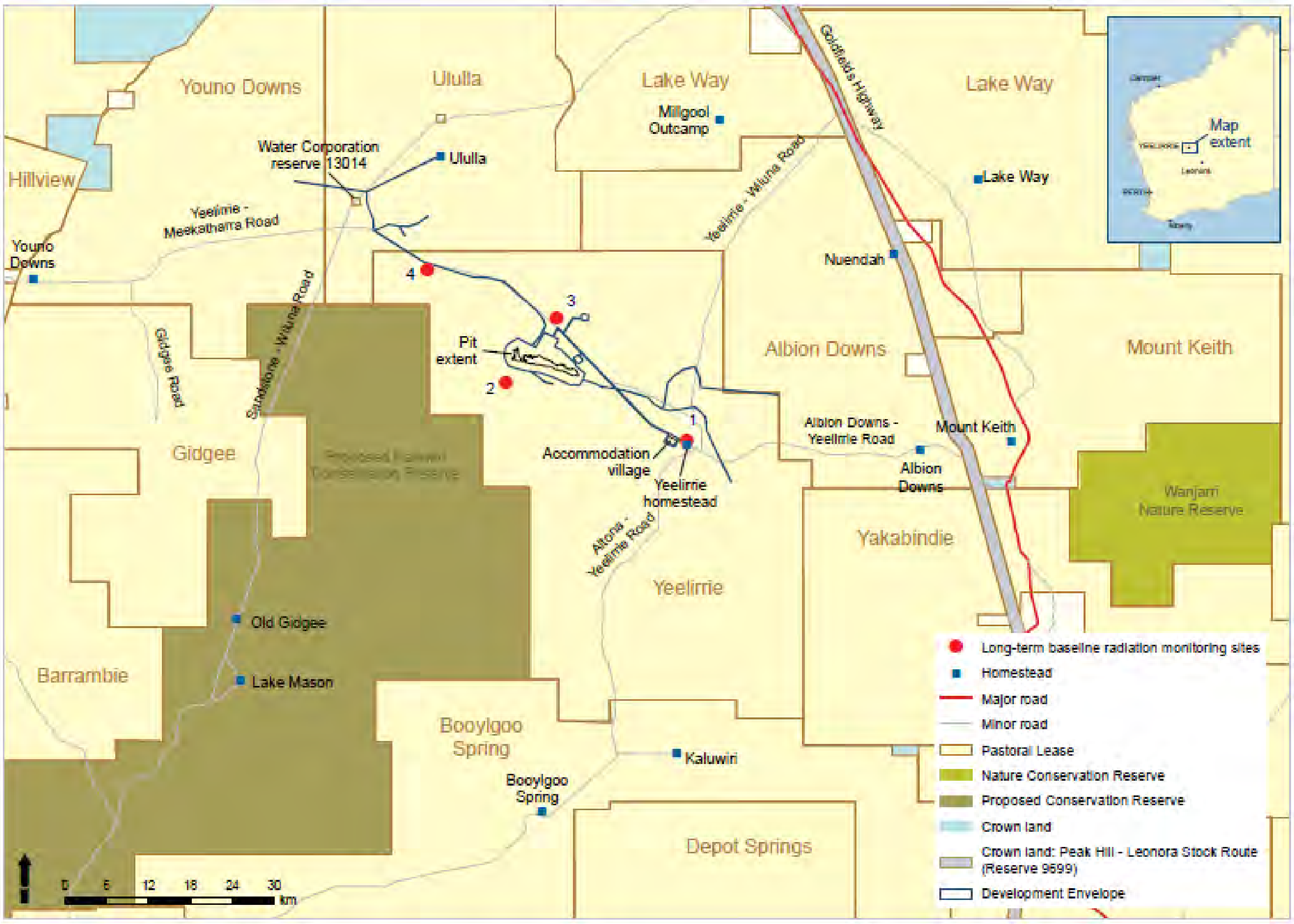


Figure 10.1: Location of long term baseline environmental radiation monitoring sites at Yeelirrie.

10.2 REPORTING

The progress and performance of progressive rehabilitation, rehabilitation monitoring sites and ongoing long term such as groundwater and radiation/dust monitoring will be reported through the Annual Environmental Report (AER) system. Rehabilitation reporting shall demonstrate that the management action has been applied and the outcome evaluated. Rehabilitation details reported in the Compliance Reports will include a summary of the rehabilitation monitoring results for the reporting period, maintenance / remedial actions completed or planned and the area and nature of any new rehabilitation that has been undertaken on-site.

Whilst compliance and performance reporting will be used to update this document every three years, it is important to note that the results of monitoring will be used internally on an annual basis to assess rehabilitation performance and identify whether alternative management strategies are required or if completion criteria require review. This is a critical component of an effective adaptive management system and the iterative feedback loop in developing effective closure criteria (Figure 6.1).

11 FINANCIAL PROVISIONING FOR CLOSURE

Definitive closure costing for the Yeelirrie project has not been determined at this stage. Preliminary closure costing based on the areas, infrastructure and volumes of material as detailed within the current mining study. Costs included in the provision encompass all closure and rehabilitation activities expected to occur progressively over the life of the operation, at the time of closure and during the post closure period (e.g. monitoring). This will include all expected indirect costs, such as project management costs, statutory reporting fees and technical support costs.

In some cases, closure estimates are based on substantial judgements as to the expectations of future mining and rehabilitation activities which will affect the amount and timing of required future cash flows. Cameco bases these judgements on existing knowledge as well as environmental, regulatory and company specific requirements. In light of the expected longevity of the life of mine, adjustments to the estimated costs and timing of closure activities are regarded as probable. Therefore Cameco seeks to include the following factors which will are likely to affect the closure costs in the process of provision for closure;

- Changes to estimated life of mine
- Developments in technology and rehabilitation process
- Changes to regulatory requirements and environmental management
- Changes to estimated extent and cost of closure activities

The closure cost estimate will be continually reviewed during refinement of the project and updated in parallel with the MCP. Changes in planned activities and understanding of rehabilitation requirements will further refine the closure estimate as the project progresses.

The closure cost estimation is simplified by dividing the various aspects of closure into discrete domains which are applied to each area of operations, these aspects are;

- Infrastructure, evaporation ponds and general land disturbance rehabilitation
- In-pit TSF and backfilled mine void rehabilitation
- Infrastructure decommissioning and removal / disposal
- Post closure monitoring costs
- Human resource costs

12 MANAGEMENT OF INFORMATION AND DATA

A closure, environment and community database will be created and maintained by Cameco to ensure that all baseline data, mining records, logistical and site procedures are housed in a centralised framework for the effective management of information and data relevant to closure. Figure 12.1 shows a schematic flow diagram that represents the conceptual process and methodology for flows between three tiers of information and decision making, consisting of:

1. Information base, e.g. baseline, logistical data
2. Closure planning and implementation by domain
3. Evaluation (3a) and compliance (3b)

The first tier is fed by existing data, records and procedures of which selected themes (represented by orange boxes) are relevant to the second tier domain specific closure planning and implementation. The third tier represents the small-scale research, monitoring and trials run in parallel with large-scale closure works for each of the domains. The information will be used to evaluate progress towards closure goals and is an important stimulus for adaptive management and remediation works by building on the existing information base through LOM (bold arrow). Reporting and compliance for the Yeelirrie Project will be ongoing to demonstrate that progress towards closure and final land-use are in line with the agreed stakeholder standards.

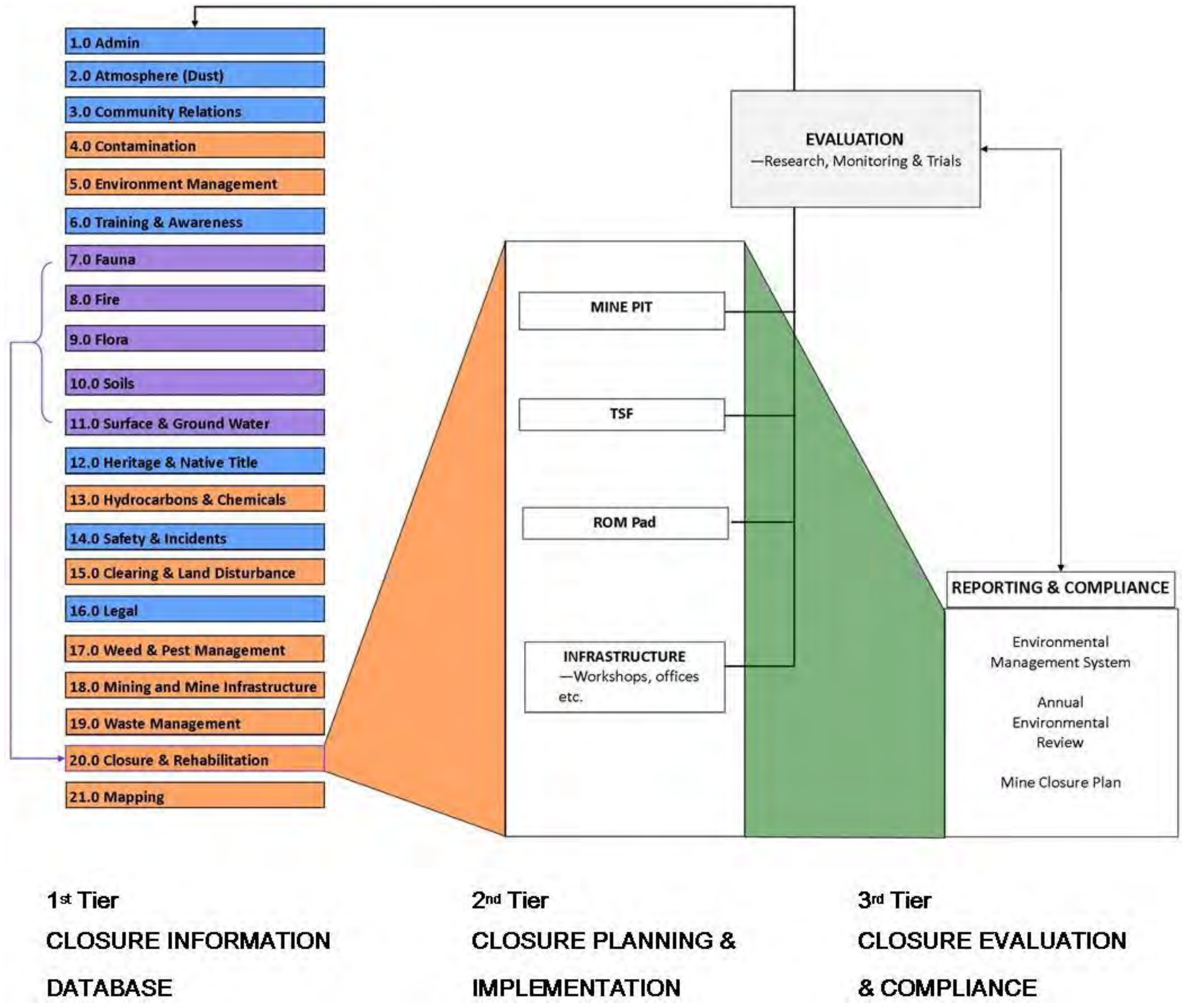


Figure 12.1: Conceptual diagram of closure database structure and management

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APPENDIX A: List of Active Leases

Lease	Lease_Type	Area_Units	Curr_Area	Grant_Date	Expiry_Date
L53/159	Lw - Misc Licence - Groundwater Search (WA)	Hectares	16,710.0	17/01/2012	16/01/2033
L53/160	Lw - Misc Licence - Groundwater Search (WA)	Hectares	19,828.0	17/01/2012	16/01/2033
L53/161	Lw - Misc Licence - Groundwater Search (WA)	Hectares	16,000.0	9/05/2013	8/05/2034
M53/1	M - Mining Lease (WA)	Hectares	120.2	9/08/1982	8/08/2024
M53/2	M - Mining Lease (WA)	Hectares	56.0	9/08/1982	8/08/2024
M53/28	M - Mining Lease (WA)	Hectares	189.4	12/12/1984	11/12/2026
MC36/2667	MC - Mineral Claim (WA)	Hectares	121.4	18/09/1973	n/a
MC36/2668	MC - Mineral Claim (WA)	Hectares	121.4	18/09/1973	n/a
MC36/2677	MC - Mineral Claim (WA)	Hectares	109.8	22/11/1973	n/a
MC36/2679	MC - Mineral Claim (WA)	Hectares	115.7	22/11/1973	n/a
MC36/2680	MC - Mineral Claim (WA)	Hectares	108.1	22/11/1973	n/a
MC36/2681	MC - Mineral Claim (WA)	Hectares	95.7	22/11/1973	n/a
MC36/2707	MC - Mineral Claim (WA)	Hectares	110.4	22/11/1973	n/a
MC36/2708	MC - Mineral Claim (WA)	Hectares	97.9	22/11/1973	n/a
MC36/2709	MC - Mineral Claim (WA)	Hectares	116.9	22/11/1973	n/a
MC36/2710	MC - Mineral Claim (WA)	Hectares	112.1	22/11/1973	n/a
MC36/2711	MC - Mineral Claim (WA)	Hectares	16.8	29/01/1974	n/a
MC36/2712	MC - Mineral Claim (WA)	Hectares	50.6	29/01/1974	n/a
MC36/2713	MC - Mineral Claim (WA)	Hectares	118.1	29/01/1974	n/a
MC36/2714	MC - Mineral Claim (WA)	Hectares	120.1	29/01/1974	n/a
MC36/2715	MC - Mineral Claim (WA)	Hectares	103.7	19/09/1973	n/a
MC36/2716	MC - Mineral Claim (WA)	Hectares	113.5	19/09/1973	n/a
MC36/2717	MC - Mineral Claim (WA)	Hectares	121.3	19/09/1973	n/a
MC36/2718	MC - Mineral Claim (WA)	Hectares	120.5	29/01/1974	n/a
MC36/2771	MC - Mineral Claim (WA)	Hectares	121.4	1/10/1973	n/a
MC36/3313	MC - Mineral Claim (WA)	Hectares	117.9	1/10/1973	n/a
MC36/3314	MC - Mineral Claim (WA)	Hectares	121.4	1/10/1973	n/a
MC36/3315	MC - Mineral Claim (WA)	Hectares	120.7	1/10/1973	n/a
MC36/3316	MC - Mineral Claim (WA)	Hectares	113.3	2/01/1974	n/a
MC36/3317	MC - Mineral Claim (WA)	Hectares	115.8	1/10/1973	n/a
MC36/3694	MC - Mineral Claim (WA)	Hectares	106.8	5/09/1975	n/a
MC53/1098	MC - Mineral Claim (WA)	Hectares	118.8	21/01/1971	n/a
MC53/1099	MC - Mineral Claim (WA)	Hectares	120.3	21/01/1971	n/a
MC53/1100	MC - Mineral Claim (WA)	Hectares	102.2	21/01/1971	n/a
MC53/1101	MC - Mineral Claim (WA)	Hectares	100.0	21/01/1971	n/a
MC53/1102	MC - Mineral Claim (WA)	Hectares	121.3	21/01/1971	n/a
MC53/1103	MC - Mineral Claim (WA)	Hectares	116.7	21/01/1971	n/a
MC53/1104	MC - Mineral Claim (WA)	Hectares	108.1	21/01/1971	n/a
MC53/1105	MC - Mineral Claim (WA)	Hectares	115.3	21/01/1971	n/a
MC53/1106	MC - Mineral Claim (WA)	Hectares	104.6	21/01/1971	n/a
MC53/1107	MC - Mineral Claim (WA)	Hectares	121.4	21/01/1971	n/a
MC53/1108	MC - Mineral Claim (WA)	Hectares	119.8	21/01/1971	n/a
MC53/1109	MC - Mineral Claim (WA)	Hectares	108.9	21/01/1971	n/a
MC53/1110	MC - Mineral Claim (WA)	Hectares	121.1	21/01/1971	n/a
MC53/1111	MC - Mineral Claim (WA)	Hectares	117.3	21/01/1971	n/a
MC53/1112	MC - Mineral Claim (WA)	Hectares	120.3	21/01/1971	n/a
MC53/1113	MC - Mineral Claim (WA)	Hectares	121.0	21/01/1971	n/a
MC53/1114	MC - Mineral Claim (WA)	Hectares	118.9	21/01/1971	n/a
MC53/1115	MC - Mineral Claim (WA)	Hectares	118.3	21/01/1971	n/a
MC53/1116	MC - Mineral Claim (WA)	Hectares	119.4	21/01/1971	n/a
MC53/1117	MC - Mineral Claim (WA)	Hectares	119.7	21/01/1971	n/a
MC53/1118	MC - Mineral Claim (WA)	Hectares	118.4	21/01/1971	n/a
MC53/1119	MC - Mineral Claim (WA)	Hectares	120.5	21/01/1971	n/a
MC53/1120	MC - Mineral Claim (WA)	Hectares	114.2	21/01/1971	n/a
MC53/1121	MC - Mineral Claim (WA)	Hectares	119.8	21/01/1971	n/a
MC53/1122	MC - Mineral Claim (WA)	Hectares	113.2	21/01/1971	n/a
MC53/1165	MC - Mineral Claim (WA)	Hectares	121.1	16/12/1970	n/a
MC53/1166	MC - Mineral Claim (WA)	Hectares	120.3	16/12/1970	n/a
MC53/1167	MC - Mineral Claim (WA)	Hectares	121.4	16/12/1970	n/a
MC53/1168	MC - Mineral Claim (WA)	Hectares	121.4	16/12/1970	n/a
MC53/1169	MC - Mineral Claim (WA)	Hectares	119.6	16/12/1970	n/a
MC53/1170	MC - Mineral Claim (WA)	Hectares	120.6	16/12/1970	n/a
MC53/1171	MC - Mineral Claim (WA)	Hectares	121.2	16/12/1970	n/a

Lease	Lease_Type	Area_Units	Curr_Area	Grant_Date	Expiry_Date
MC53/1172	MC - Mineral Claim (WA)	Hectares	115.4	16/12/1970	n/a
MC53/1173	MC - Mineral Claim (WA)	Hectares	117.4	16/12/1970	n/a
MC53/1174	MC - Mineral Claim (WA)	Hectares	115.4	16/12/1970	n/a
MC53/1175	MC - Mineral Claim (WA)	Hectares	114.2	16/12/1970	n/a
MC53/1176	MC - Mineral Claim (WA)	Hectares	111.3	18/05/1972	n/a
MC53/1177	MC - Mineral Claim (WA)	Hectares	119.4	18/05/1972	n/a
MC53/1178	MC - Mineral Claim (WA)	Hectares	119.9	16/12/1970	n/a
MC53/1179	MC - Mineral Claim (WA)	Hectares	119.7	16/12/1970	n/a
MC53/1180	MC - Mineral Claim (WA)	Hectares	117.4	16/12/1970	n/a
MC53/1181	MC - Mineral Claim (WA)	Hectares	117.4	16/12/1970	n/a
MC53/1182	MC - Mineral Claim (WA)	Hectares	117.2	16/12/1970	n/a
MC53/1183	MC - Mineral Claim (WA)	Hectares	116.3	16/12/1970	n/a
MC53/1184	MC - Mineral Claim (WA)	Hectares	120.3	16/12/1970	n/a
MC53/1185	MC - Mineral Claim (WA)	Hectares	110.2	16/12/1970	n/a
MC53/1186	MC - Mineral Claim (WA)	Hectares	106.0	16/12/1970	n/a
MC53/1187	MC - Mineral Claim (WA)	Hectares	116.8	16/12/1970	n/a
MC53/1188	MC - Mineral Claim (WA)	Hectares	120.1	16/12/1970	n/a
MC53/1189	MC - Mineral Claim (WA)	Hectares	120.8	16/12/1970	n/a
MC53/1190	MC - Mineral Claim (WA)	Hectares	121.3	16/12/1970	n/a
MC53/1191	MC - Mineral Claim (WA)	Hectares	118.8	16/12/1970	n/a
MC53/1192	MC - Mineral Claim (WA)	Hectares	121.2	16/12/1970	n/a
MC53/1193	MC - Mineral Claim (WA)	Hectares	120.8	16/12/1970	n/a
MC53/1194	MC - Mineral Claim (WA)	Hectares	118.1	16/12/1970	n/a
MC53/1196	MC - Mineral Claim (WA)	Hectares	121.1	16/12/1970	n/a
MC53/1197	MC - Mineral Claim (WA)	Hectares	121.1	16/12/1970	n/a
MC53/3147	MC - Mineral Claim (WA)	Hectares	110.1	13/06/1972	n/a
MC53/3148	MC - Mineral Claim (WA)	Hectares	120.8	13/06/1972	n/a
MC53/3149	MC - Mineral Claim (WA)	Hectares	120.4	13/06/1972	n/a
MC53/3150	MC - Mineral Claim (WA)	Hectares	116.9	13/06/1972	n/a
MC53/3151	MC - Mineral Claim (WA)	Hectares	114.3	13/06/1972	n/a
MC53/3152	MC - Mineral Claim (WA)	Hectares	116.2	13/06/1972	n/a
MC53/3153	MC - Mineral Claim (WA)	Hectares	114.8	13/06/1972	n/a
MC53/3767	MC - Mineral Claim (WA)	Hectares	106.1	23/05/1973	n/a
MC53/3768	MC - Mineral Claim (WA)	Hectares	115.6	23/05/1973	n/a
MC53/3769	MC - Mineral Claim (WA)	Hectares	115.8	23/05/1973	n/a
MC53/3770	MC - Mineral Claim (WA)	Hectares	115.3	23/05/1973	n/a
MC53/3771	MC - Mineral Claim (WA)	Hectares	120.6	23/05/1973	n/a
MC53/3772	MC - Mineral Claim (WA)	Hectares	109.6	23/11/1973	n/a
MC53/3773	MC - Mineral Claim (WA)	Hectares	118.6	23/05/1973	n/a
MC53/3774	MC - Mineral Claim (WA)	Hectares	118.7	23/05/1973	n/a
MC53/3775	MC - Mineral Claim (WA)	Hectares	116.4	23/05/1973	n/a
MC53/3776	MC - Mineral Claim (WA)	Hectares	120.1	23/05/1973	n/a
MC53/3780	MC - Mineral Claim (WA)	Hectares	117.3	23/05/1973	n/a
MC53/3781	MC - Mineral Claim (WA)	Hectares	118.8	23/05/1973	n/a
MC53/3782	MC - Mineral Claim (WA)	Hectares	121.3	23/05/1973	n/a
MC53/3783	MC - Mineral Claim (WA)	Hectares	119.6	23/05/1973	n/a
MC53/3784	MC - Mineral Claim (WA)	Hectares	120.2	23/05/1973	n/a
MC53/3785	MC - Mineral Claim (WA)	Hectares	120.8	24/01/1973	n/a
MC53/3834	MC - Mineral Claim (WA)	Hectares	119.7	4/08/1972	n/a
MC53/3835	MC - Mineral Claim (WA)	Hectares	121.1	4/08/1972	n/a
MC53/3836	MC - Mineral Claim (WA)	Hectares	118.7	24/08/1973	n/a
MC53/3837	MC - Mineral Claim (WA)	Hectares	116.9	4/08/1972	n/a
MC53/3838	MC - Mineral Claim (WA)	Hectares	119.7	24/08/1972	n/a
MC53/3839	MC - Mineral Claim (WA)	Hectares	121.0	4/08/1972	n/a
MC53/3840	MC - Mineral Claim (WA)	Hectares	121.3	4/08/1972	n/a
MC53/3841	MC - Mineral Claim (WA)	Hectares	117.8	4/08/1972	n/a
MC53/3845	MC - Mineral Claim (WA)	Hectares	121.1	24/08/1973	n/a
MC53/3846	MC - Mineral Claim (WA)	Hectares	120.1	24/08/1973	n/a
MC53/3871	MC - Mineral Claim (WA)	Hectares	121.3	25/09/1972	n/a
MC53/3872	MC - Mineral Claim (WA)	Hectares	121.3	25/09/1972	n/a
MC53/3873	MC - Mineral Claim (WA)	Hectares	121.0	25/09/1972	n/a
MC53/3874	MC - Mineral Claim (WA)	Hectares	121.0	25/09/1972	n/a
MC53/3877	MC - Mineral Claim (WA)	Hectares	121.2	25/09/1972	n/a

Lease	Lease_Type	Area_Units	Curr_Area	Grant_Date	Expiry_Date
MC53/3878	MC - Mineral Claim (WA)	Hectares	121.2	25/09/1972	n/a
MC53/3904	MC - Mineral Claim (WA)	Hectares	83.2	13/06/1972	n/a
MC53/3905	MC - Mineral Claim (WA)	Hectares	117.9	13/06/1972	n/a
MC53/3906	MC - Mineral Claim (WA)	Hectares	121.0	22/01/1973	n/a
MC53/3908	MC - Mineral Claim (WA)	Hectares	121.2	22/01/1973	n/a
MC53/3909	MC - Mineral Claim (WA)	Hectares	120.7	13/06/1972	n/a
MC53/3911	MC - Mineral Claim (WA)	Hectares	121.2	13/06/1972	n/a
MC53/3912	MC - Mineral Claim (WA)	Hectares	118.8	13/06/1972	n/a
MC53/3914	MC - Mineral Claim (WA)	Hectares	121.1	13/06/1972	n/a
MC53/3919	MC - Mineral Claim (WA)	Hectares	121.3	13/06/1972	n/a
MC53/3927	MC - Mineral Claim (WA)	Hectares	121.3	14/03/1973	n/a
MC53/3929	MC - Mineral Claim (WA)	Hectares	119.6	14/03/1973	n/a
MC53/3931	MC - Mineral Claim (WA)	Hectares	121.3	14/03/1973	n/a
MC53/3933	MC - Mineral Claim (WA)	Hectares	117.3	16/06/1972	n/a
MC53/3934	MC - Mineral Claim (WA)	Hectares	105.0	16/06/1972	n/a
MC53/3939	MC - Mineral Claim (WA)	Hectares	120.5	28/08/1972	n/a
MC53/3940	MC - Mineral Claim (WA)	Hectares	120.9	28/08/1972	n/a
MC53/3941	MC - Mineral Claim (WA)	Hectares	120.7	28/08/1972	n/a
MC53/3942	MC - Mineral Claim (WA)	Hectares	120.8	28/08/1972	n/a
MC53/3943	MC - Mineral Claim (WA)	Hectares	121.3	28/08/1972	n/a
MC53/3974	MC - Mineral Claim (WA)	Hectares	120.8	13/05/1972	n/a
MC53/3976	MC - Mineral Claim (WA)	Hectares	120.9	13/05/1972	n/a
MC53/3978	MC - Mineral Claim (WA)	Hectares	121.4	13/05/1972	n/a
MC53/3979	MC - Mineral Claim (WA)	Hectares	120.4	13/05/1972	n/a
MC53/3981	MC - Mineral Claim (WA)	Hectares	121.2	31/05/1972	n/a
MC53/3989	MC - Mineral Claim (WA)	Hectares	118.2	31/05/1972	n/a
MC53/3990	MC - Mineral Claim (WA)	Hectares	120.1	31/05/1972	n/a
MC53/4060	MC - Mineral Claim (WA)	Hectares	116.1	22/11/1973	n/a
MC53/4062	MC - Mineral Claim (WA)	Hectares	118.1	22/11/1973	n/a
MC53/4063	MC - Mineral Claim (WA)	Hectares	119.3	22/11/1973	n/a
MC53/4064	MC - Mineral Claim (WA)	Hectares	107.9	22/11/1973	n/a
MC53/4065	MC - Mineral Claim (WA)	Hectares	106.8	22/11/1973	n/a
MC53/4115	MC - Mineral Claim (WA)	Hectares	121.3	7/11/1973	n/a
MC53/4126	MC - Mineral Claim (WA)	Hectares	113.2	22/01/1973	n/a
MC53/4127	MC - Mineral Claim (WA)	Hectares	101.7	26/09/1973	n/a
MC53/4358	MC - Mineral Claim (WA)	Hectares	115.1	23/05/1973	n/a
MC53/4359	MC - Mineral Claim (WA)	Hectares	114.6	23/05/1973	n/a
MC53/4360	MC - Mineral Claim (WA)	Hectares	109.4	23/05/1973	n/a
MC53/4529	MC - Mineral Claim (WA)	Hectares	117.3	26/01/1973	n/a
MC53/4530	MC - Mineral Claim (WA)	Hectares	99.2	26/01/1973	n/a
MC53/4531	MC - Mineral Claim (WA)	Hectares	111.5	22/02/1973	n/a
MC53/4536	MC - Mineral Claim (WA)	Hectares	120.9	28/02/1973	n/a
MC53/4538	MC - Mineral Claim (WA)	Hectares	121.2	28/02/1973	n/a
MC53/4803	MC - Mineral Claim (WA)	Hectares	18.1	11/07/1975	n/a
MC53/4804	MC - Mineral Claim (WA)	Hectares	36.5	27/08/1975	n/a
MC53/4805	MC - Mineral Claim (WA)	Hectares	93.8	11/07/1975	n/a
MC53/5303	MC - Mineral Claim (WA)	Hectares	120.0	12/12/1978	n/a
MC53/5304	MC - Mineral Claim (WA)	Hectares	120.0	12/12/1978	n/a
MC53/5305	MC - Mineral Claim (WA)	Hectares	120.0	12/12/1978	n/a
MC53/5306	MC - Mineral Claim (WA)	Hectares	120.0	12/12/1978	n/a
MC53/5307	MC - Mineral Claim (WA)	Hectares	114.0	12/12/1978	n/a
MC53/5308	MC - Mineral Claim (WA)	Hectares	120.0	12/12/1978	n/a
MC53/5309	MC - Mineral Claim (WA)	Hectares	120.0	12/12/1978	n/a
MC53/5310	MC - Mineral Claim (WA)	Hectares	120.0	9/11/1978	n/a
MC53/5311	MC - Mineral Claim (WA)	Hectares	114.0	12/12/1978	n/a
MC53/5312	MC - Mineral Claim (WA)	Hectares	114.0	12/12/1978	n/a
MC53/5313	MC - Mineral Claim (WA)	Hectares	120.0	12/12/1978	n/a
MC53/5314	MC - Mineral Claim (WA)	Hectares	120.0	12/12/1978	n/a
MC53/5315	MC - Mineral Claim (WA)	Hectares	111.1	12/12/1978	n/a
MC53/5316	MC - Mineral Claim (WA)	Hectares	110.6	12/12/1978	n/a
MC53/5317	MC - Mineral Claim (WA)	Hectares	120.6	12/12/1978	n/a
MC53/5318	MC - Mineral Claim (WA)	Hectares	118.3	12/12/1978	n/a
MC53/5319	MC - Mineral Claim (WA)	Hectares	104.8	12/12/1978	n/a

APPENDIX A: List of Active Leases

Lease	Lease_Type	Area_Units	Curr_Area	Grant_Date	Expiry_Date
MC53/5320	MC - Mineral Claim (WA)	Hectares	121.2	12/12/1978	n/a
MC53/5321	MC - Mineral Claim (WA)	Hectares	120.0	12/12/1978	n/a
TR70/6899	TR - Temporary Reserve (WA)	Hectares	51,550.0	1/11/1978	n/a