Section 6

The Project

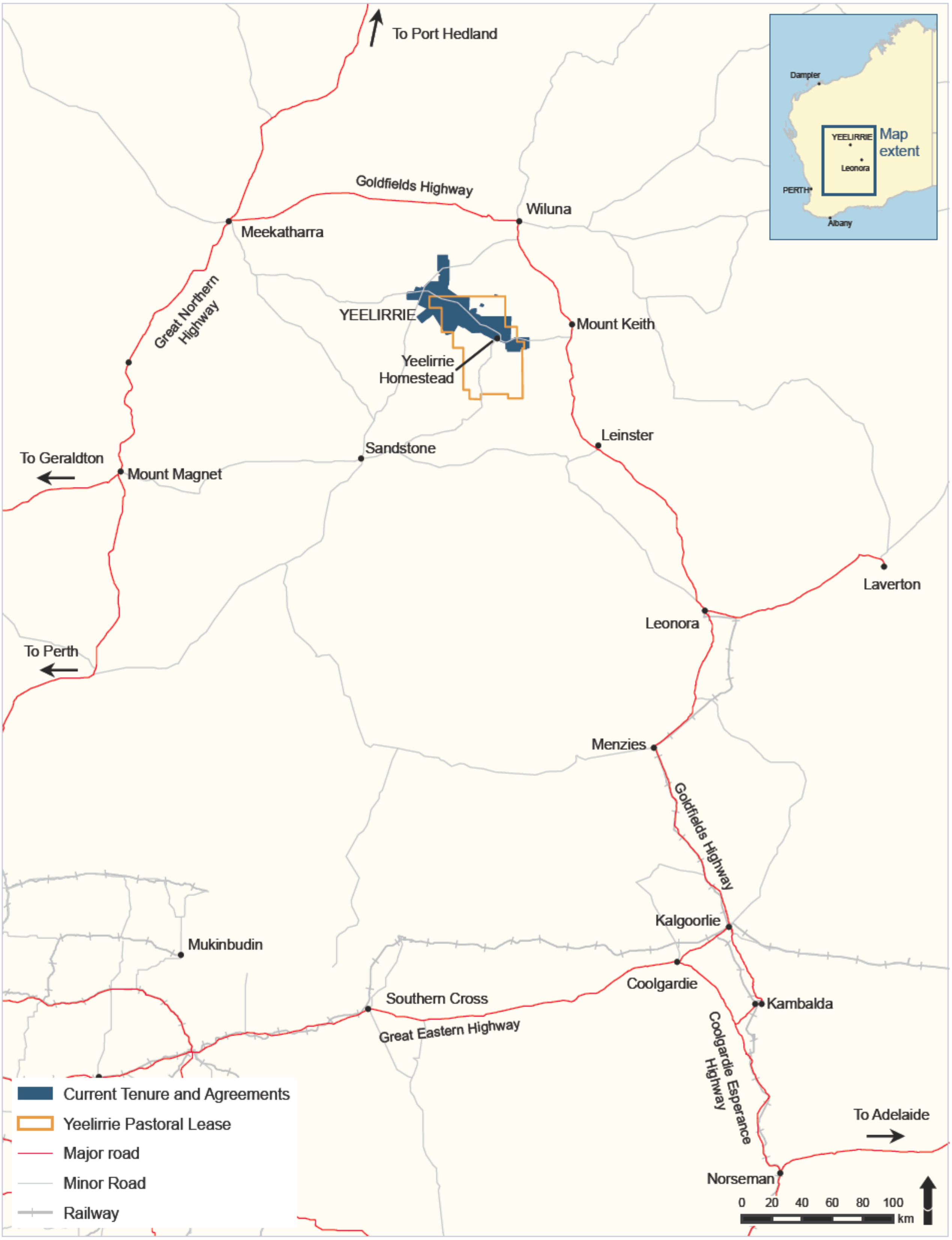


Figure 6-1: Location of the proposed Yeelirrie development in a regional context

6. The Project

6.1 Project Overview

Cameco proposes to develop an open pit mine and associated processing facilities at Yeelirrie in the Northern Goldfields region of Western Australia, approximately 420 km north of Kalgoorlie-Boulder, 65 km west of Mount Keith, 70 km south west of Wiluna and 110 km north west of Leinster (Figure 6-1).

The proposed development would produce up to 7,500 tonnes or 16.5 Mlbs per year of uranium oxide concentrate (UOC) as $UO_4.2H_2O$. Production will peak at this level in the second year of ore processing and steadily decline as the grade of the ore reduces over the 15 year ore processing period. The average annual production over the 15 year ore processing period will be approximately 3,850 tonnes or 8.48 Mlbs of UOC as $UO_4.2H_2O$.

The open pit mine would be about 9 km long, up to 1.5 km wide and about 15 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. Ore would be stockpiled and subsequently treated in the proposed metallurgical plant. The mined material would be stockpiled near the open pit before being processed within the metallurgical plant, or backfilled into the pit, if it is not economic to process.

The metallurgical plant would use an alkali tank leaching process, followed by direct precipitation, to produce UOC for containerised export from Port Adelaide. All tailings generated during the metallurgical processing of the ore would be returned to the tailings storage facility (TSF) constructed within the two open pits.

The proposed development would necessitate the construction and operation of infrastructure required to support mining and processing, including the supply of water and electricity, workforce accommodation and infrastructure to transport the product. The main components of the infrastructure are as follows:

- 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;
- water supply wellfield 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 stockpiled ore;
- electricity supply network powered by a series of on-site diesel (or gas fired) generators;
- buildings, including workshops, offices and warehouses;
- accommodation village catering for a peak on-site construction workforce of up to 1,200; and
- associated infrastructure including potable water and sewage treatment plants.

At the completion of operations, the development infrastructure would be decommissioned and removed and the site rehabilitated. In addition to the tailings, any remaining low-grade ore stockpiles and potentially radioactive materials, including processing facilities, would be buried in the pit and then covered with original mined materials (e.g. overburden) and topsoils. The cover for the mine would be designed to be safe, stable and non-polluting. Disturbed areas would be recontoured and rehabilitated as far as practicable with endemic, self-sustaining vegetation.

The proposed development would also use, where practicable, existing regional and national infrastructure, including:

- the road and rail network between Perth, Esperance, and Kalgoorlie-Boulder for the import of materials;
- facilities at the port of Adelaide for the export of UOC; and
- airport facilities at the BHP Billiton Nickel West Pty Ltd Mount Keith operation, coupled to a proposed bus service between Mount Keith and Yeelirrie for the movement of a fly-in/fly-out (FIFO) workforce.

The key characteristics of the proposed development are summarised in Table 6-1 and 6-2 and are shown on Figures 6-2 and 6-3.

Table 6-1: **Proposal summary and key characteristics of the proposed development**

Proposal Title:		Yeelirrie Uranium Project
Proponent Name:		Cameco Australia Pty Ltd
Short Description:		The proposal is to mine uranium ore from the Yeelirrie deposit, approximately 70 km south west of Wiluna, and the construction of associated mine infrastructure, including ore processing facilities, water abstraction and reinjection infrastructure, roads, accommodation, offices and workshops, stockpile and laydown areas and evaporation pond. Tailings will be discharged back into the mine open pit.
Physical Elements		
Element	**Location**	**Proposed Extent**
Mine Open Pit	See Figure 6.3	Clearing of approximately 725.9 ha within a 4,874.6 ha development envelope and no deeper than 15 m below ground level.
Associated Infrastructure	See Figure 6.3	Clearing of approximately 1,695.9 ha within a 4,874.6 ha development envelope.
Operational Elements		
Element	**Location**	**Proposed Extent**
Mining Rate	Mining with conventional equipment	Up to 14 Mtpa of mineralised ore and non-mineralised material (annual average of approximately 8 Mt).
Ore Processing (waste)	All tailings deposited in open pit	Deposition of up to approximately 3.0 Mtpa.
Water Abstraction	Dewatering of pits and production from borefield. See Figure 6.2	Extraction of up to approximately 4.9 GL/a.
Water Reinjection		Reinjection of up to approximately 1.3 Gl/a. (1)
GL/a – gigalitres per annum		Ha – hectares
m – metres		Mtpa – million tonnes per annum

Notes:

[1] In the early phase of the project, pit dewatering volumes exceed water demands. The surplus water would be re-injected into the local calcrete aquifer within the confines of the mine footprint.

Table 6-2: Other project characteristics

Non-spatial elements	Description
Development operating life	An operational life of 22 years, including 3 years of pre-production dewatering, mining and construction followed by a further 12 years of mining and 15 years of processing. The conclusion of processing would be followed by an estimated 4 years of decommissioning and rehabilitation.
Nature of mineralisation	Shallow-depth alluvial deposit with mineralisation starting from surface to about 15 m below ground level, with a thickness between about 1 to7 m.
Operations summary	Open pit mining and on-site processing of uranium mineralised ore to produce uranium oxide concentrate.
Mining method	Open pit mining using conventional equipment such as excavators, front-end loaders and haul trucks.
Processing method	Alkali leach and direct precipitation.
Production rate	Up to 7,500 tpa of uranium oxide concentrate produced at peak production in the second year of ore processing. The average annual production over the 15 year ore processing period will be approximately 3,850 tonnes or 8.48 Mlbs of UOC as $UO_4.2H_2O$.
Tailings management	In-pit disposal to an engineered tailings storage facility.
Quarry	A quarry supplying approximately 500,000 tonnes of crushed rock material would be located about 8 km north of the processing plant.
Waste management facility	A waste management facility would be established on the mining lease, approximately 4 km south east of the metallurgical plant.
Water supply	The development's primary water supply would be sourced from the initial dewatering of the open pit mine and then, as dewatering rates decreased, water would be piped from a network of groundwater wells. Obtaining water from this source would require the construction of pipeline and associated pumping infrastructure.
Annualised (over the 15 year process plant life) average water demand (ML/d)	8.7 ML/d (3.2 GL/a)
Maximum electricity demand (MW)	20
Average electricity consumption (MWh/a)	150,000
Maximum diesel demand (KL/a)	80,000 (excluding product transport diesel)
Accommodation village	A village would be constructed about 20 km east of the processing plant, with sufficient accommodation for up to 1,200 people, which would be downsized after construction.
Peak construction workforce	1,200
Average construction workforce	500
Peak operational workforce	300
Average operational workforce	225

6.1.1 Project Timeline

This section provides an indication of proposed timing. The commencement of the development schedule will ultimately depend on the timing and nature of government approvals and the final investment decision by the Cameco Board.

The Yeelirrie Uranium Project has a construction, operation, decommissioning and closure timeline of 22 years. If the Project were approved, Cameco would complete planning activities, including a Definitive Feasibility Study (DFS) and detailed project design, before the proposed timeline would commence.

Cameco plans to mine the deposit through a number of staged phases of dewatering and mining, which are summarised below.

The Project would start with the dewatering of Stage 1 of the open pit. Mining Block 1 would be pre-stripped down to the ore body and the material stockpiled. Ore would then be mined down to the water table then stockpiled. Once the water table has been reached, dewatering trenches would be established and the mining block would be dewatered by pumping water from the trenches. This would continue for about 12 months before the commencement of mining of ore from below the water table. During this time, site infrastructure construction would also commence. Once Stage 1 of the open pit is safely dewatered, mining would continue. Mining and stockpiling would continue for a further 12 months to establish a cell within the open pit void suitable to receive and store tailings. During that period the metallurgical plant would be constructed and commissioned.

Initial mining would target areas of higher-grade ore. Mining of the open pit is expected to take 15 years to exhaust the ore. The metallurgical plant would continue to treat ore from stockpiles for another two years. The open pit would be progressively rehabilitated as the pit void is filled with tailings from the metallurgical plant and capped with stockpiled mined materials. At the completion of ore processing, the plant would be disassembled and disposed of into the pit void before being covered and capped with mined material. Backfilling, mine closure and rehabilitation are expected to take a further four years.

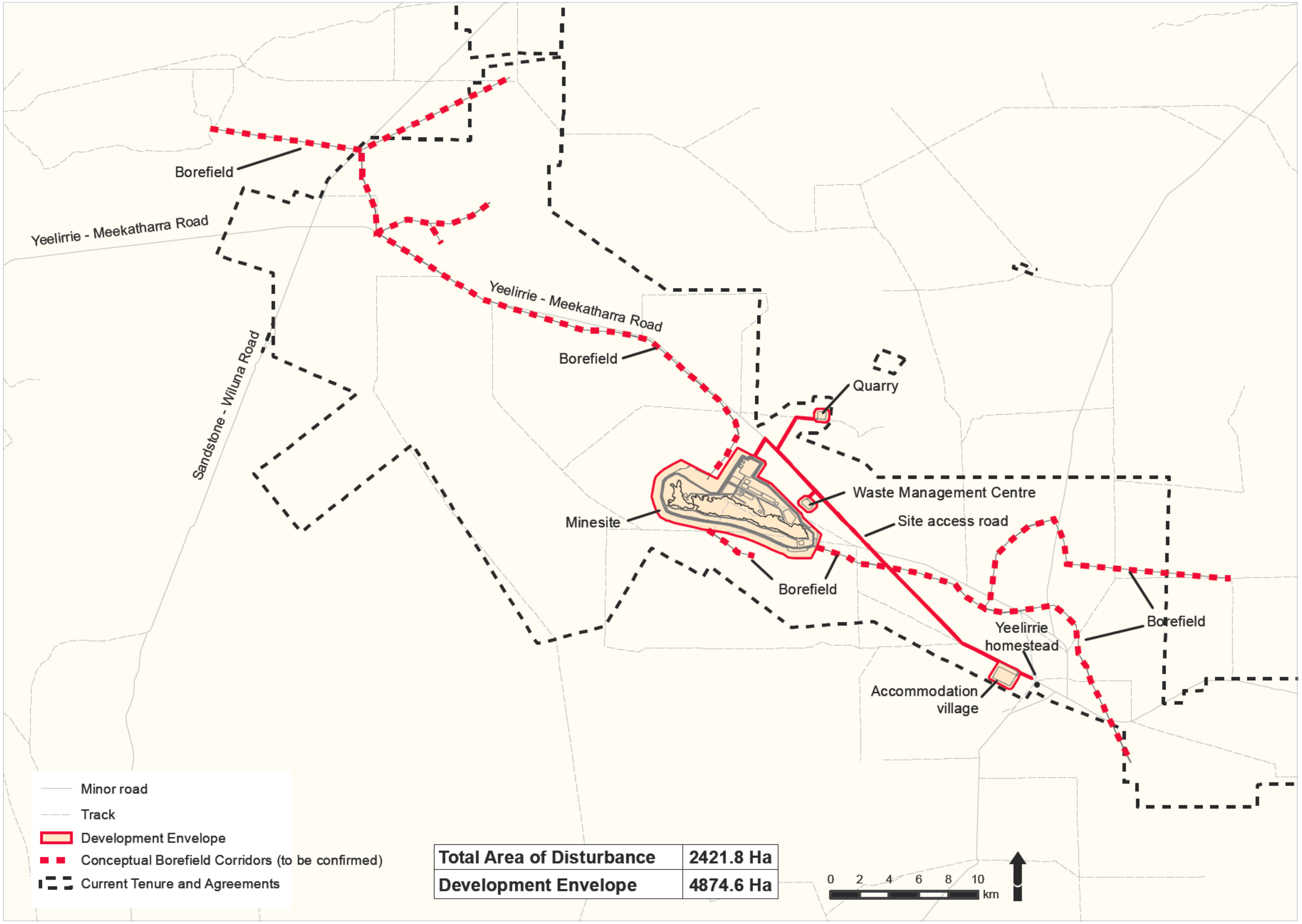
Figure 6-4 shows the Project timeline and Figures 6-5 and 6-6 show a conceptual layout of the Project at approximately Year 2 and Year 10.

6.2 The Resource

The Yeelirrie uranium deposit is the largest known uranium deposit in Western Australia. It occurs in calcrete hosted material in the central drainage channel of a wide, flat and long valley which is flanked by granitic breakaways of low topographic relief with elevations between 490 m AHD and 610 m AHD (see Figure 6-7).

The mineralisation extends from the surface to an approximate depth of 10 m, with the main concentration centred about 4 m below the surface, with a thickness ranging from 1 to 7 m (see Figure 6-8). The surface extent of the identified resource is 9 km long and an average of 1 km wide, with a maximum width of about 1.5 km.

The resource is sufficient to provide approximately 15 years of ore to the metallurgical processing plant at a nominal processing rate of 2.4 Mtpa.



Total Area of Disturbance	2421.8 Ha
Development Envelope	4874.6 Ha

Figure 6-2: Proposed Yeelirrie minesite elements regional setting

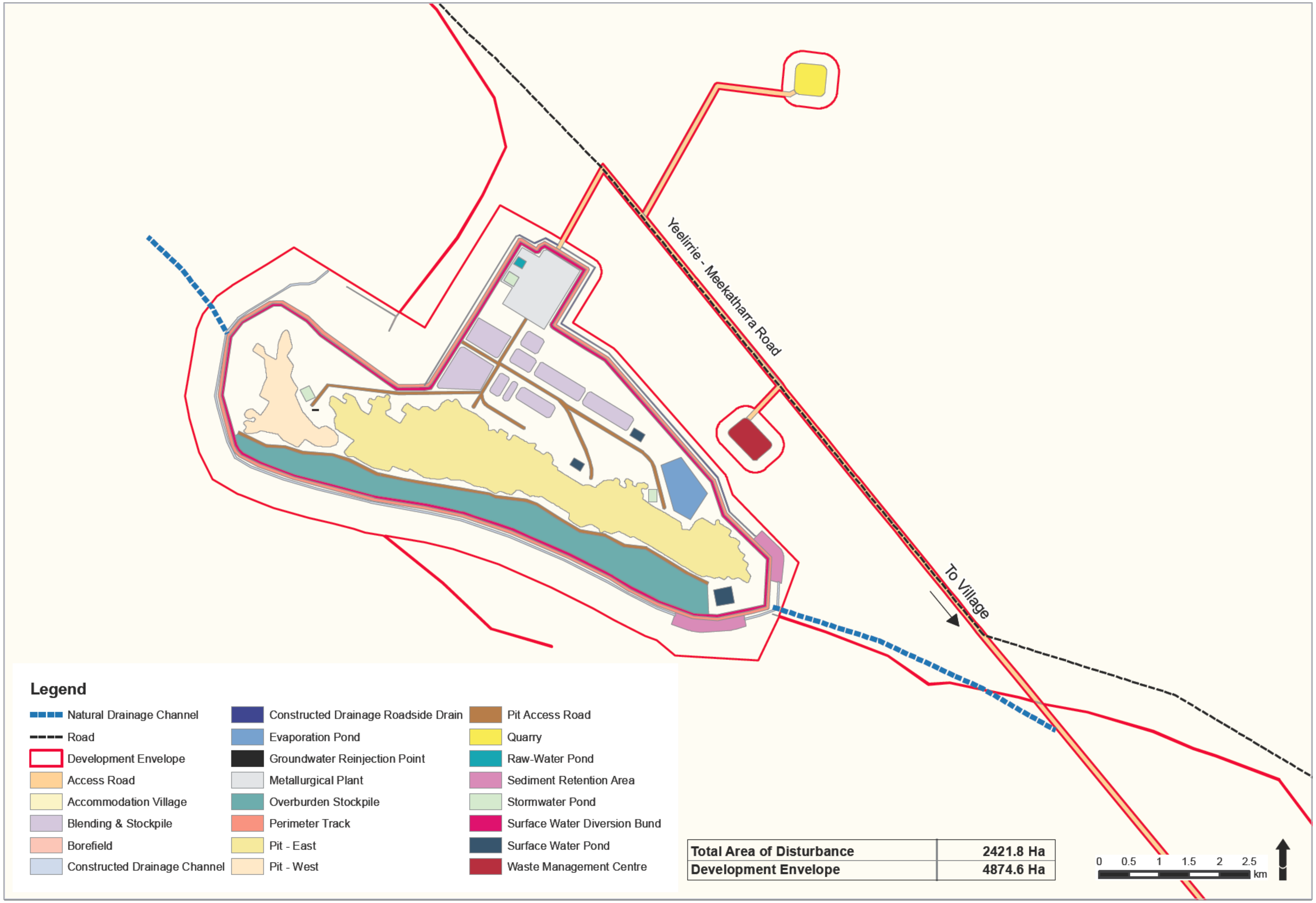
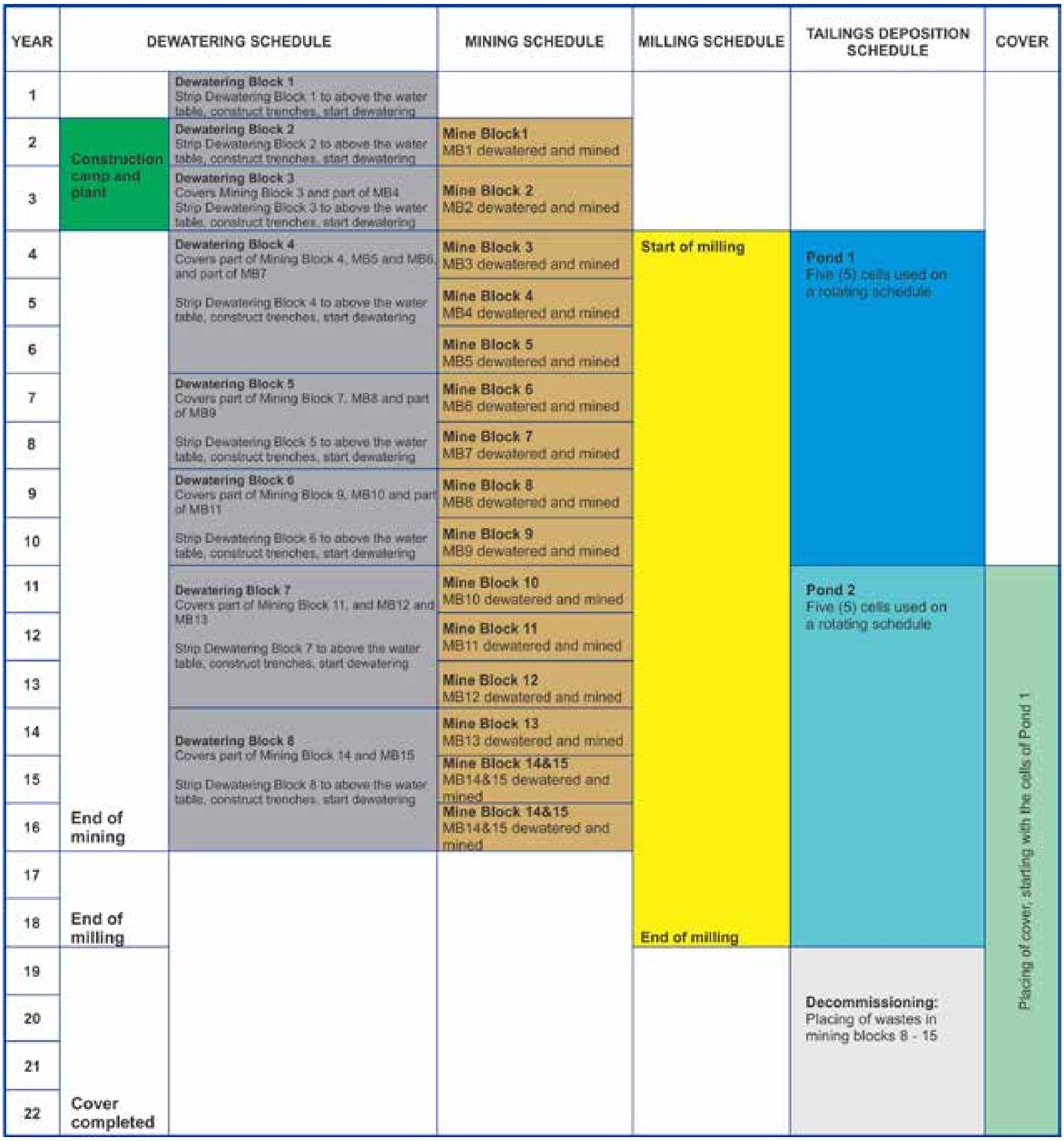


Figure 6-3: Proposed Yeelirrie minesite elements



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 6-4: Indicative project timeline

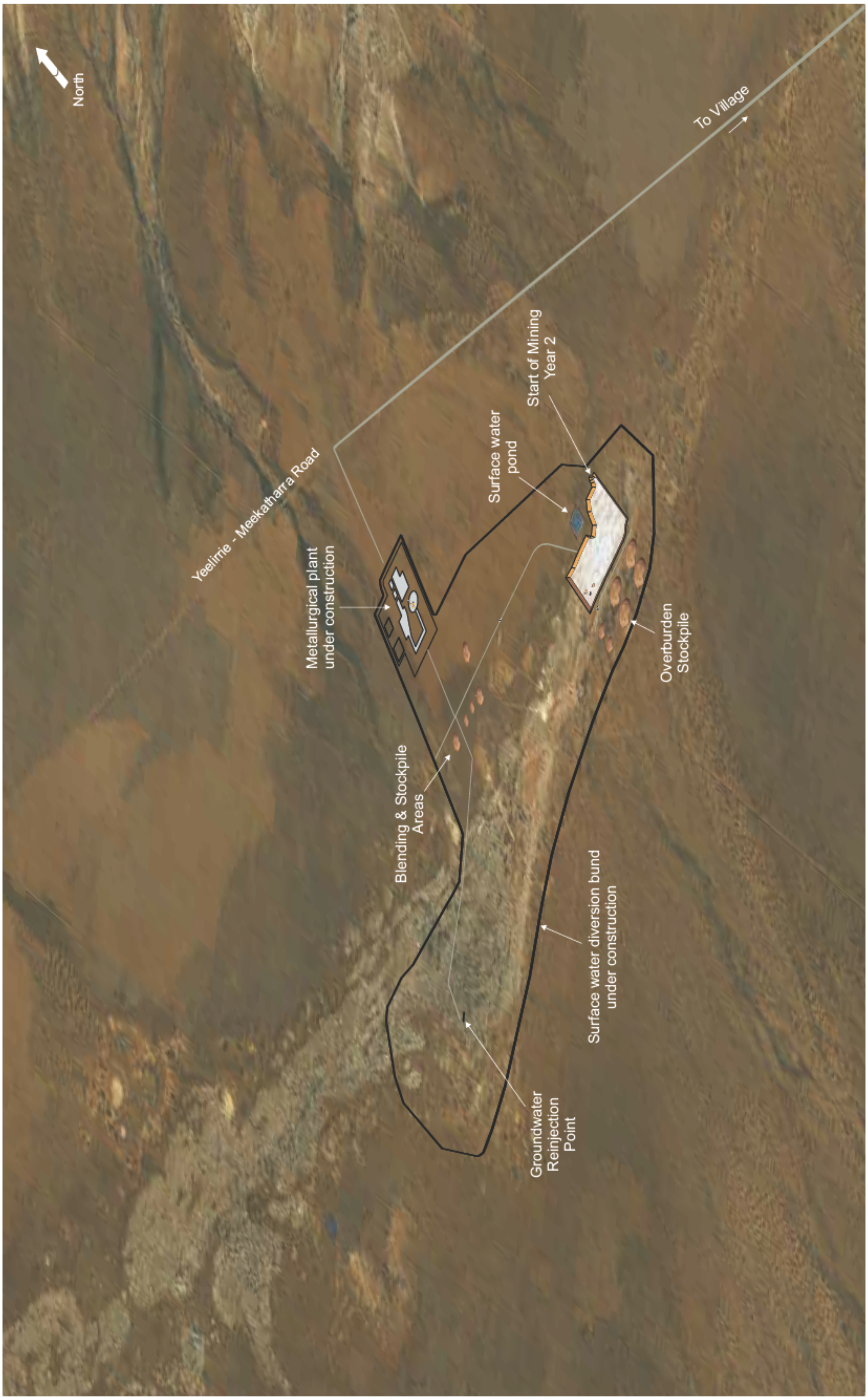


Figure 6-5: Mine site development at year 2

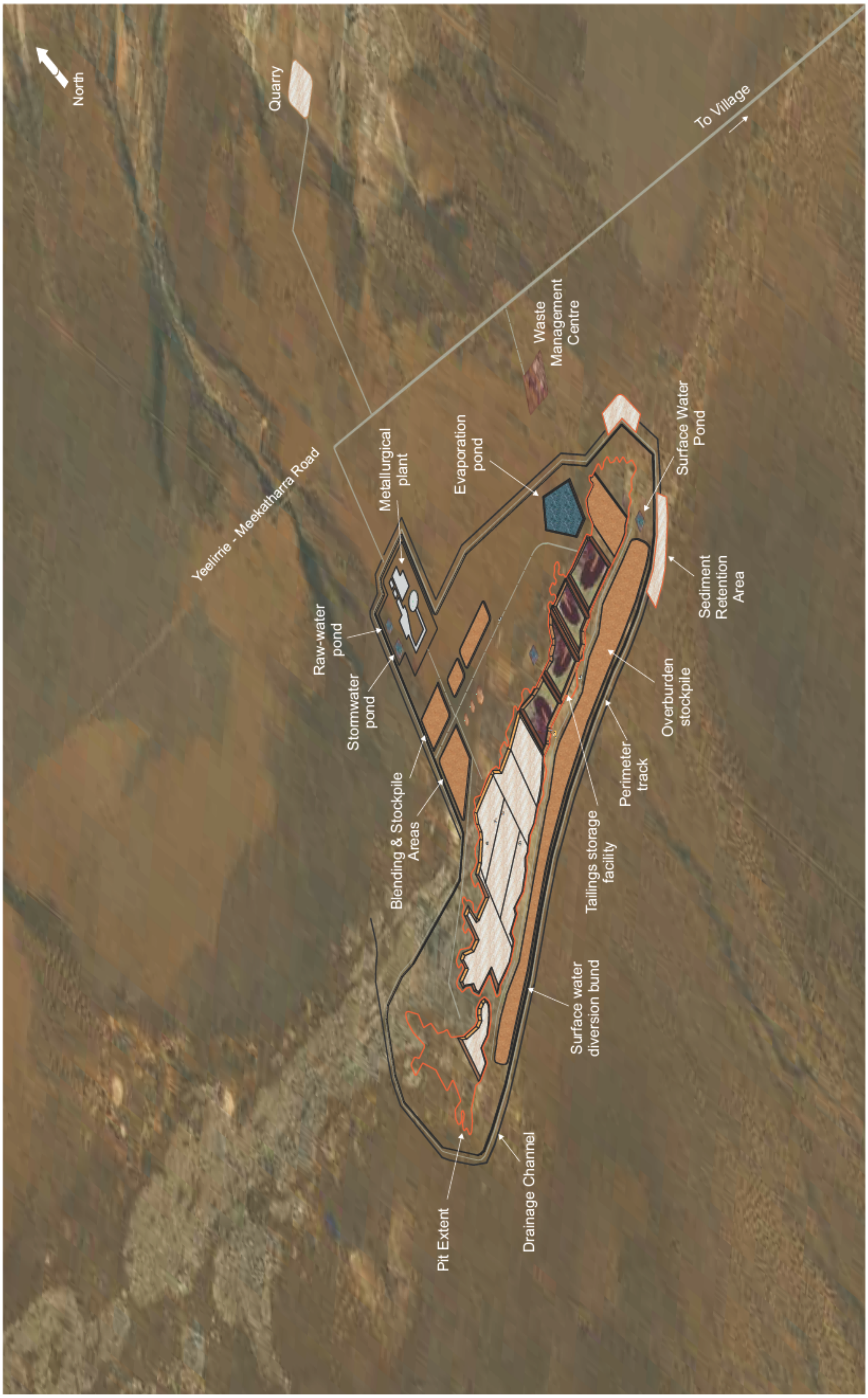


Figure 6-6: Mine site development at year 10

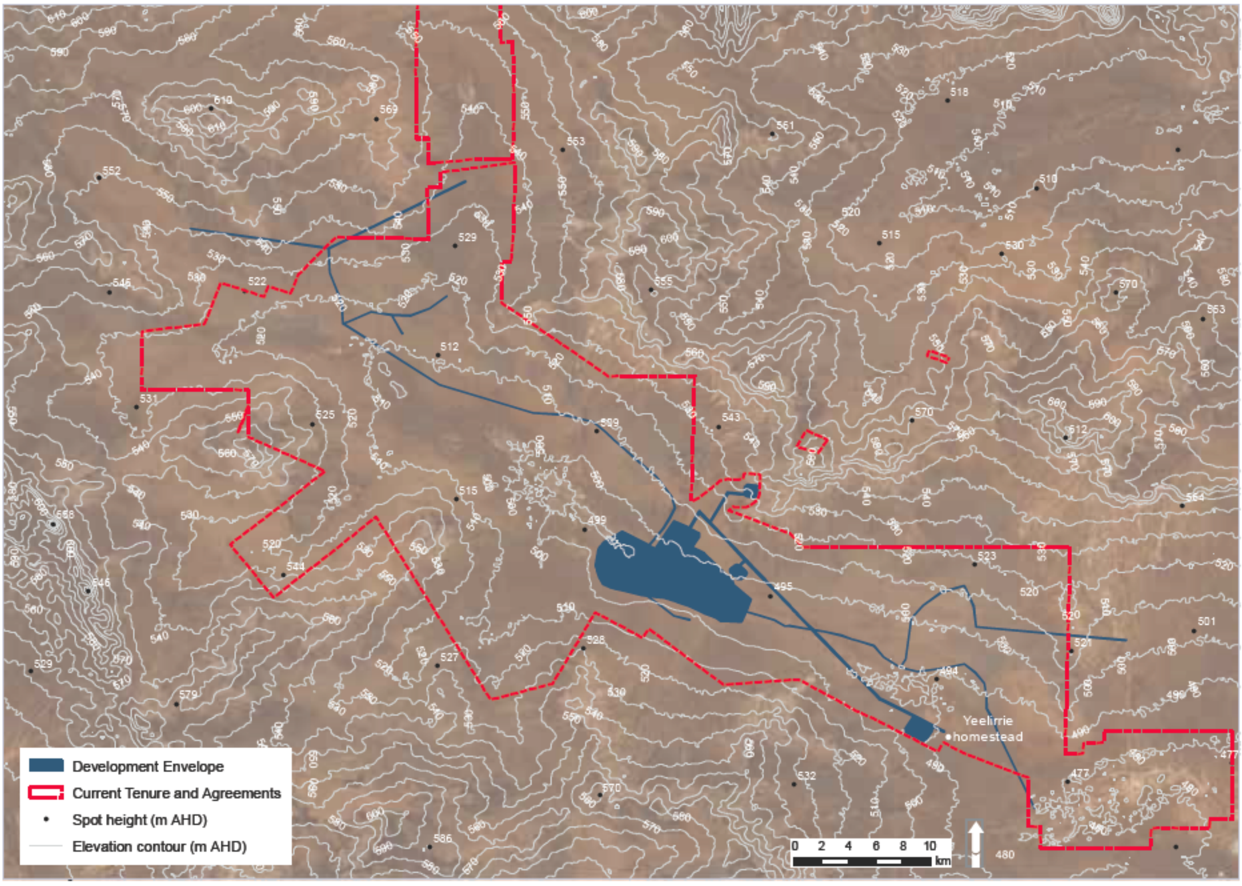


Figure 6-7: Yeelirrie orebody in a local context

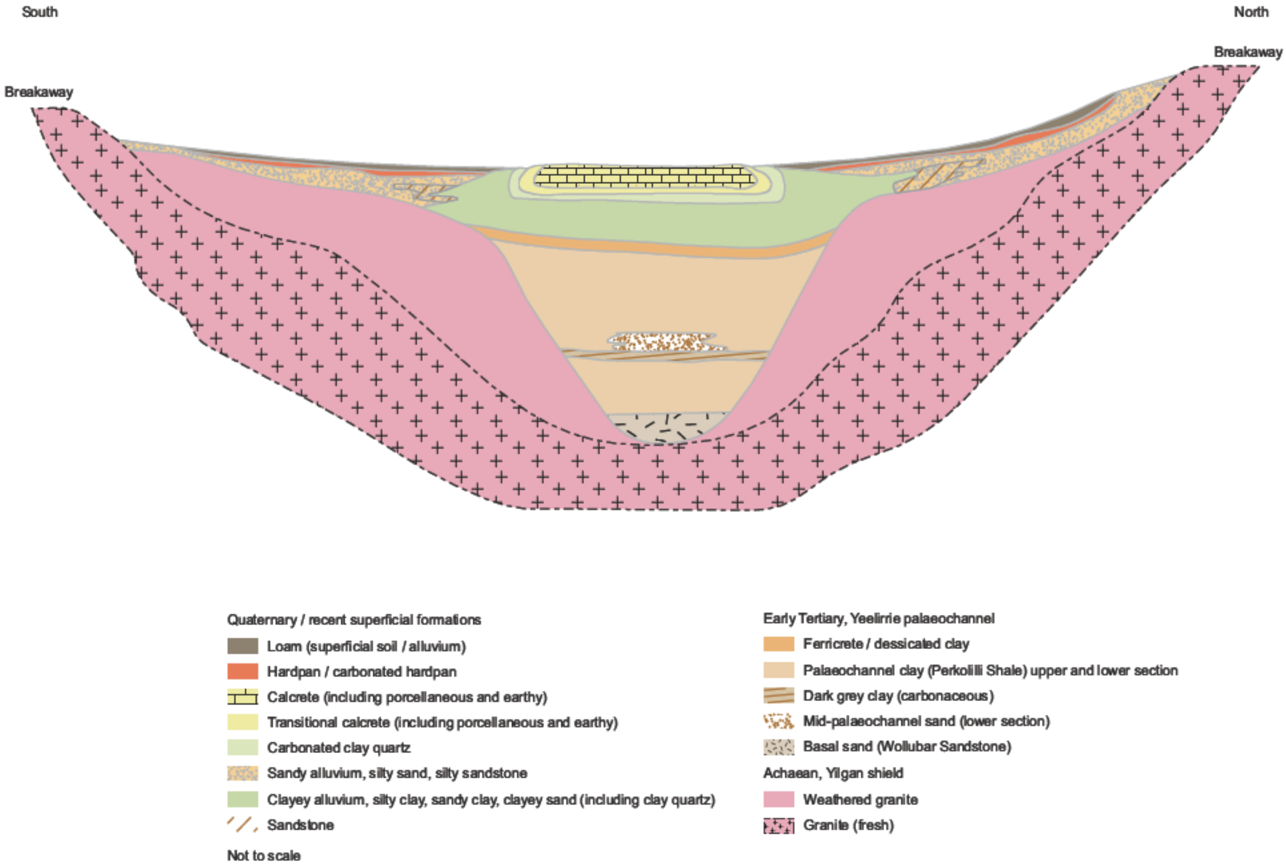


Figure 6-8: Conceptual cross-section of the Yeelirrie orebody

6.2.1 Lithology and Mineralogy

Lithological and mineralogical studies conducted in the Yeelirrie valley (WMC 1975, and studies conducted for this PER) show that there are four principal lithological units at the proposed development site:

1. Overburden: consisting of a combination of sandy loam, siliceous and ferruginous cemented hard-pan and carbonated loam, which is probably a weathered calcrete.
2. Calcrete: a calcite and/or dolomite replacement of the clay-quartz, although relics of partially replaced clay-quartz are common throughout the calcrete. The upper portion of the calcrete comprises friable 'earthy calcrete', a continuous layer grading upwards into the overlying soils. Nodular porcellanous calcrete represents the lower layer of the calcrete and consists of up to 70% carbonate (McKay and Miezitis 2001).
3. Clay-quartz: a kaolinitic clay-quartz alluvial fill material. Bands of quartz grit and arkose are randomly scattered through the clay-quartz as horizontal beds. Upper clays are predominantly montmerillonite, with kaolinite becoming more abundant at depth.
4. Archaean granitic basement complex: generally seen in drill holes at depths of around 30 m below the surface near the ore body.

Uranium mineralisation occurs as carnotite, a potassium uranyl vanadate ($K_2(UO_2)_2(VO_4)_2.3H_20$), which is found in the overburden and clay quartz unit. However, mineralisation is richest within the calcrete and transitional calcrete material. It typically fills fractures and voids, occurring as a coating on surfaces and as a very fine-grained dispersion through the mineralised units. Although found throughout the 'earthy calcrete' and the nodular porcellanous calcrete, approximately 90% of the ore is in the clay-rich carbonated rocks of the transition zone at the base of the calcrete unit.

Uranium mineralisation in the (mainly) calcrete is related to groundwater levels and chemistry. Key processes involved in the precipitation of uranium mineralisation can be summarised as:

- oxidation of mildly reducing uranium, potassium and vanadium-bearing waters, either by direct contact with air, or by mixing with more oxidised surface water; and
- evaporation concentration of water during drier climate cycles or along the flow path towards salt lakes.

The majority of the uranium mineralisation occurs beneath the water table due to the leaching of uranium by carbon dioxide in rainfall infiltrating from the surface.

6.2.2 Geochemistry

The geological database, derived from drill cores from the deposit, provides the following general observations about the distribution and variability of key elements within the different lithological units:

- Many metals (e.g. vanadium, copper, nickel and lead) are present at low concentrations in all units, with median concentrations below crustal averages. Concentrations are lowest in calcrete, and highest in the deeper clay-quartz lithologies. There appears to be some correlation between these metals and aluminium and silicon content, suggesting clays may be important as sorption sites (e.g. ion exchange).
- Median arsenic and molybdenum contents are generally less than 20 ppm and 5 ppm, respectively. Crustal average values for arsenic and molybdenum are 1.5 ppm. Highest median contents are found in the deeper clay-quartz lithologies.

6.3 Mining

Mining of the pit would use standard surface mining equipment, such as excavators and front-end loaders in conjunction with haul trucks and scrapers, to remove the ore and overburden. Due to the typically high friability of the ore and overburden material, minimal drilling and blasting would be required, although this technique may be needed in areas of the open pit if hard rock was encountered. For the purpose of the impact assessment presented in this document, a realistic worst-case scenario has been adopted, whereby 16 blasts are undertaken each year, using a total of about 70 tonnes of explosives and emulsion product.

Given the shallow nature and relatively small footprint of the area being mined at any time, the total mining fleet would consist of 3 to 6 excavators, or similar surface mining equipment, feeding about 12 haul trucks. Standard surface mining support fleet would include water trucks, graders, drill rigs and bulldozers. The major features of the proposed open pit are summarised in Table 6-3. From the open pit, ore will be trucked to various stockpile areas based on grade and other geochemical characteristics.

Table 6-3: Features of the open pit development

Features	Proposed Development
Mining method	Open pit
Nominal mine life (years)	Up to 15
Maximum mining rate (Mtpa)	Up to 14
Average mining rate (Mtpa)	8
Length of ore body (km)	9
Average/maximum width of the ore body (km)	1 to 1.5
Average pit depth (m)	10

6.3.1 Construction Phase

The construction activities associated with the development of the open pit are discussed in the following sections.

6.3.1.1 Site Preparation

Site preparation activities would be conducted before, and concurrently with, the progressive mining activities across the Project Area. Areas to be disturbed, and 'no-go areas' to be retained (e.g. areas that support significant flora species that would be retained within the perimeter bund), would be outlined by survey and with survey pegs and flagging tape before ground disturbance commenced. Vegetation would be cleared and topsoil stripped and stockpiled for reuse as the mine was progressively developed. The topsoil would be placed in specific stockpiles and managed to maintain the ecological viability of the seed-stock contained within it.

Internal roads would be established for hauling ore and waste, linking the open pit to the metallurgical plant and stockpiles of ore and mined material. Where possible, haul roads would be established within the ultimate footprint of the open pit to reduce the extent of vegetation disturbance. Service roads for light vehicles would be constructed to a smaller footprint to minimise the extent of vegetation disturbance.

6.3.1.2 Quarry

A quarry would be required to provide materials for the construction of internal roads, laydown and sealed hardstand areas and other civil works. It is expected that about 500,000 t of material would be extracted from the quarry, requiring a site of around 10 ha to be excavated to an average depth of 5 m. The quarried material would be crushed on-site to produce aggregate.

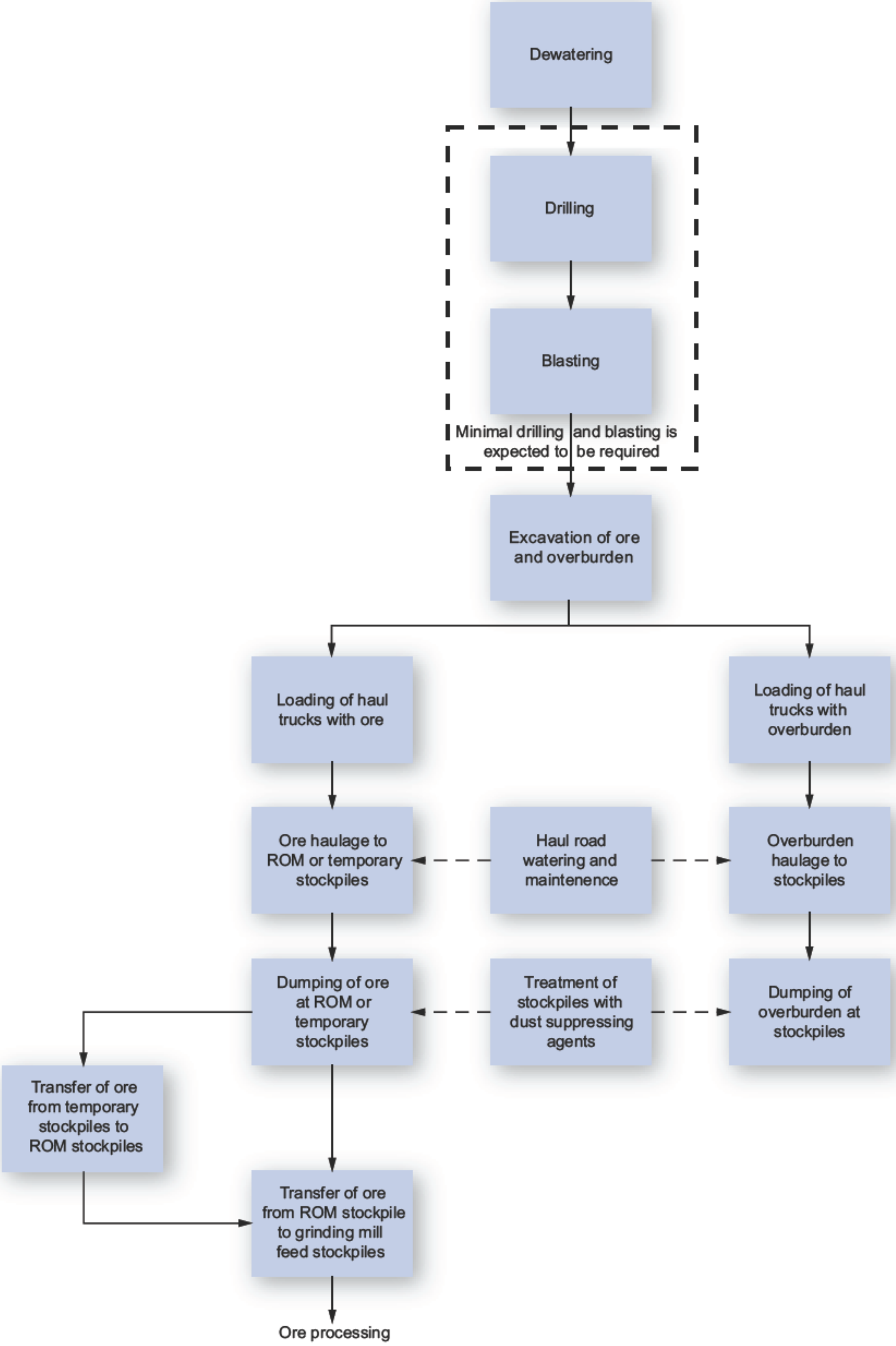


Figure 6-9: Proposed mining process flow diagram

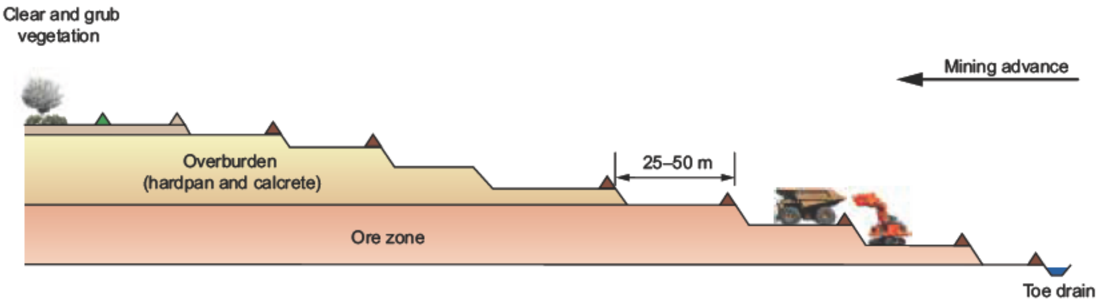


Figure 6-10: Conceptual mining operation cross-section

The quarry would primarily operate during the construction phase of the proposed Yeelirrie development, and then periodically as required for site maintenance purposes. The quarry would be located within the existing quarry lease area and would be sited to avoid identified surface water drainage channels and sites of Aboriginal cultural heritage significance.

6.3.1.3 Pit Dewatering

Pit dewatering would commence before and continue during the ongoing mining operation, details of which are provided in Section 6.6.1.

6.3.2 Operational Phase

6.3.2.1 Mining Operation

The operation of the proposed open pit would use conventional bulk mining techniques, as shown on a flow chart in Figure 6-9 and illustrated conceptually in Figure 6-10.

The open pit would be mined via a series of horizontal benches, called flitches, until the bottom of the ore body was reached. Each flitch would be divided into zones based on grade and geological classifications, and the mined material would be delivered to stockpiles or final landform destinations. Ore-grade material mined from the open pit would either be sent directly to the metallurgical plant run-of-mine (ROM) stockpile, or be stockpiled according to ore grade and geological ranges at locations accessible for subsequent handling. This approach allows for the blending of materials to ensure a consistent ore grade and geological classification feed to the metallurgical plant, which maximises processing efficiency. Stockpile foundations would be compacted before the placement of mined materials and water run-off traps would be constructed to assist in stormwater management, allowing captured water to be reused within the metallurgical plant or for dust suppression.

If dewatering using trenches, as described in Section 6.1.1, is not successful in lowering the water table below the mining level and it was necessary to excavate ore from below the water table, this ore would be placed on higher benches to drain inside the pit before being stockpiled outside the pit perimeter. This would be a precautionary measure to minimise the potential for seepage of contaminants from stockpiles to the groundwater.

Pre-stripping and mining would commence about two years before the commissioning (i.e. testing) of the metallurgical plant. The proposed mining sequence would preferentially target the highest-grade ore within the ore body, as shown conceptually as Block #1 in Figure 6-11, and would then progress east and west as Block #1 was mined out. Once mining had begun within a block required for tailings storage, it would continue to be mined to its full depth (nominally 8 to 10 m). The Block #1 void would be used to dispose of the initial tailings generated from the metallurgical plant. The pit would advance from east to west, at a rate at least sufficient to allow for the disposal of tailings throughout the life-of-mine. Section 6.5 describes the construction, operation and closure of the

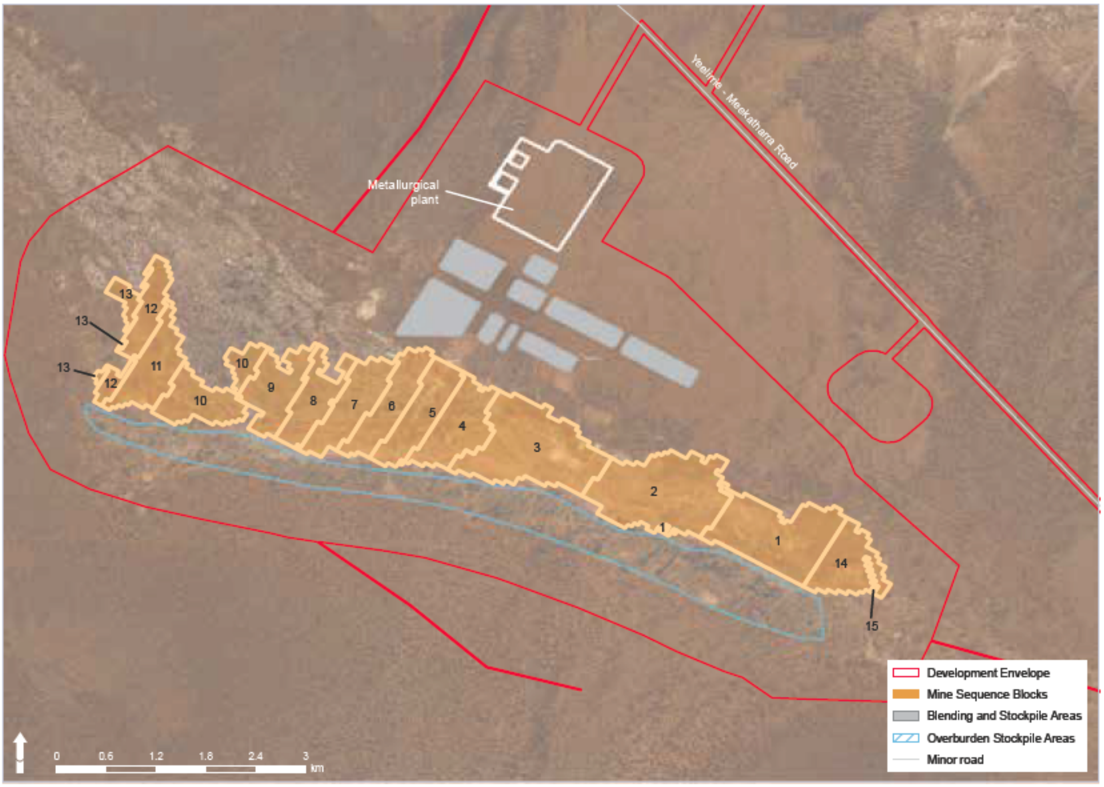


Figure 6-11: Indicative plan for excavation

proposed tailings storage facility. Ore material from the open pit operation would be extracted to balance the feed requirements of the metallurgical plant. Non-economic material would be extracted as required to uncover the economic ore and to meet the requirement for material to construct and extend the surface water diversion bund infrastructure.

6.3.2.2 Stockpile Rehandling Operations

Each stockpile of ore would be no higher than 20 m, with the stockpile locations optimised within the Project footprint. Stockpiles would be managed so that stocks of high-grade material would be stockpiled for no more than 36 months and medium-grade materials for no more than 12 years. Low-grade and non-economic materials may be stockpiled for the life of the operation, depending on the progress of rehabilitation activities and the economics associated with the processing of the lower-grade ore.

A dust suppressing material such as hydromulch may be applied to stockpiles to reduce the potential for wind erosion and reduce the demand for dust suppression water.

Stockpiled ores would be loaded by excavators or loaders into haul trucks and relocated to a blended ore stockpile near the grinding mills, from which it would be fed via front-end loader through a sizing grate and onto a feed conveyor for delivery to the grinding mill. The blended ore stockpile would be used to ensure the material feed to the metallurgical plant was of uniform grade, enabling the plant to operate more consistently and with greater recovery of uranium.

6.4 Ore Processing

A metallurgical plant would be established to treat ore extracted from the open pit at a nominal rate of 2.4 Mtpa and producing up to 7,500 tpa of UOC, and over the 15 year ore processing period averaging approximately 3,850 tonnes of UOC, depending on the uranium grade of the ore.

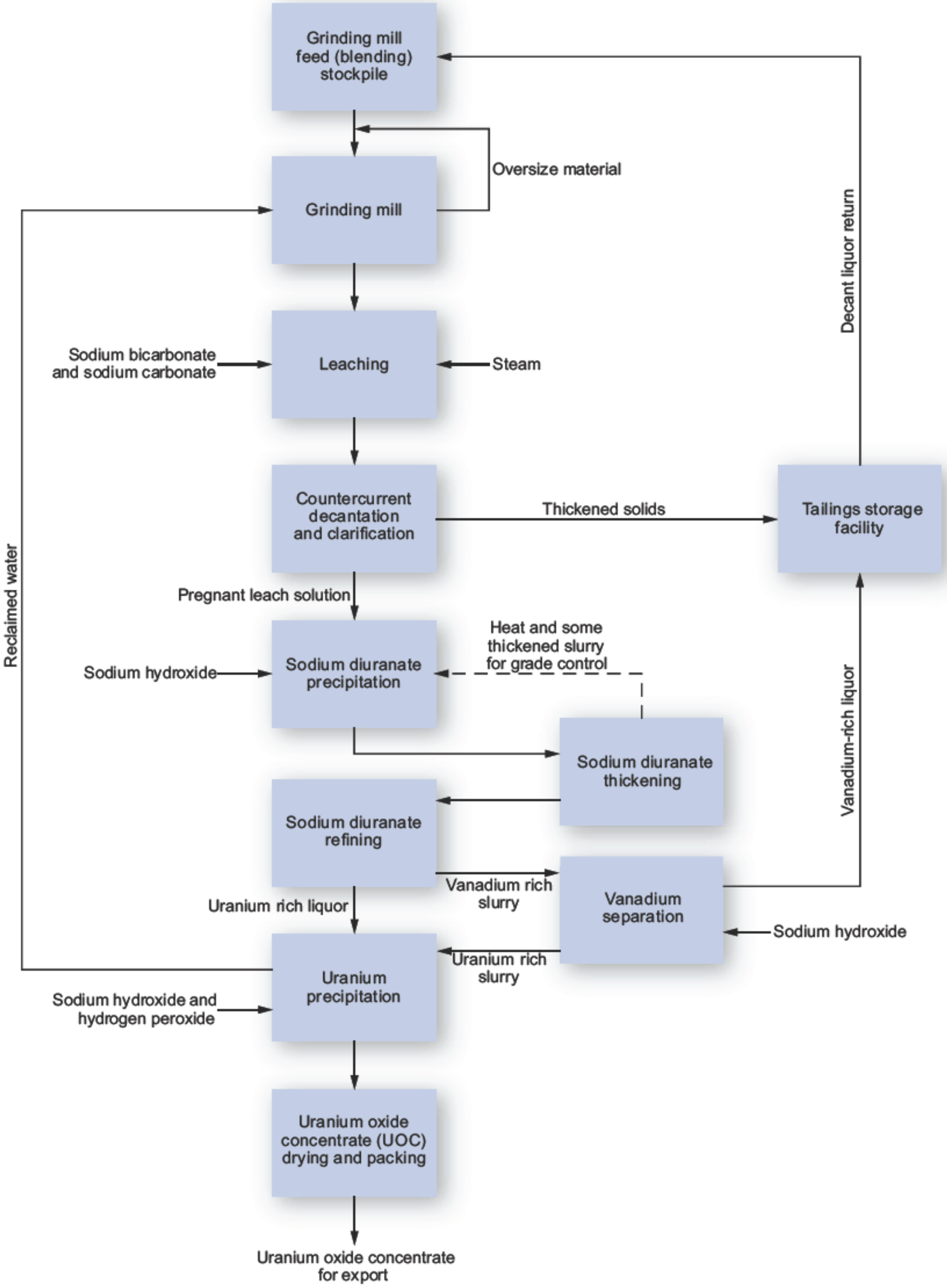


Figure 6-12: Proposed metallurgical process flow diagram

Uranium would be extracted from the ore in a series of agitated and heated alkali leaching tanks. To optimise uranium extraction, the feed material from the grinding mill feed (or blending) stockpiles would be ground to reduce the particle size before leaching. The leach residue would be separated from the uranium solution (termed pregnant leach solution, PLS) and washed in a counter-current decantation (CCD) circuit. Uranium would be precipitated from the PLS as an impure sodium diuranate (SDU), and subsequently dissolved and purified before being precipitated a second time as uranium peroxide ($UO_4.2H_2O$). This would then be dewatered, dried and packed as UOC.

A summary of the major features of the proposed metallurgical plant is provided in Table 6-4.

Table 6-4: Features of the metallurgical plant

Features	Proposed Development
Nominal metallurgical plant life (years)	15
Uranium oxide concentrate production (tpa)	Up to 7,500
Summary of uranium extraction process	Alkali leach
Summary of uranium purification process	Direct precipitation

6.4.1 Construction Phase

The completion of construction of the metallurgical plant would be timed to coincide with the completion of construction of the first tailings storage facility cell in mining Block #1.

Construction of the metallurgical plant would begin with ground preparation for foundations. Where feasible, suitable non-mineralised material (i.e. overburden) from the initial mining activities would be used for foundations. This would be supplemented, if necessary, with material extracted from the proposed quarry. Vegetation would be cleared and topsoil removed and stockpiled for reuse in progressive rehabilitation or landscaping. Graders, front-end loaders and bulldozers would be used for site preparation, levelling and grading. The selection of appropriate foundations for the metallurgical plant would not be finalised until the detailed design stage but, normally, concrete foundations would be installed over a rock or compacted soil base. The fabrication and erection of buildings would follow, including the installation of pre-assembled modules that had been delivered to site, in addition to the mechanical, piping, electrical and instrumentation components of the plant. Containment bunding would be established around all process material vessels and reagent storage areas in accordance with relevant legislative requirements.

6.4.2 Operational Phase

The proposed metallurgical plant would operate continuously (24 hours a day, 7 days a week) for approximately 15 years. The metallurgical process is illustrated in Figure 6-12, and detailed in the following sections.

6.4.2.1 Ore Storage and Milling

Run-of-mine (ROM) ore would be delivered to a number of blending stockpiles with a combined storage equivalent of up to ten days of metallurgical plant throughput. Ore would be loaded by a front-end loader into an ore bin fitted with a sizing grate, from where it would be fed directly to the milling circuit via a feeder conveyor to the mill. The design may include a system to mix the ore with water, allowing finer materials to be pumped directly to the mill as a slurry. Oversized material that was too large to pass through the sizing grate would be allowed to accumulate and would be crushed on a campaign basis using mobile crushing equipment or a rock breaker. Alternatively, a mineral sizer may be used as a primary crusher to crush oversize material on a continuous basis, negating the need for campaign crushing of the oversize material.

A single-stage Semi Autogenous Grinding (SAG) mill, or a SAG mill and Ball mill configuration, would be used to grind the ore to a fine particle size. The mill discharge slurry would be classified through screens or cyclones, with the oversized material being directed back to the grinding mill. Water reclaimed from the tailings storage facility (TSF) and other recycled process streams would be added to the resultant fine material to create a slurry of around 30 to 55% solids density.

6.4.2.2 Leaching

Slurry from the grinding mill would be mixed with sodium carbonate and sodium bicarbonate to facilitate uranium extraction during the leaching stage. The slurry would be preheated via a series of heat exchangers that would reclaim the heat from the discharge slurry generated in the hot leach stage, minimising the requirement for additional raw steam originating from the boilers.

Leaching would be done at elevated temperatures in a series of six agitated tanks. Steam would be used to increase the temperature of the pre-heated slurry to around 95°C, at which temperature the uranium within the ore would be dissolved into solution. The slurry discharge from the leach tanks would pass through the heat exchangers before the counter-current decantation (CCD) stage.

6.4.2.3 Counter-current Decantation and Clarification

A number of thickeners would be operated in series using a solution of water and carbonated barren solution, with the addition of flocculant to facilitate the separation of the uranium-bearing PLS from the solid material. The thickened solids would be pumped to a residue tank before disposal in the TSF, and the PLS would progress to a clarifier, where additional flocculent and coagulant would be added to extract the last of the solid material from the PLS.

6.4.2.4 Sodium Diuranate Precipitation

Clarified PLS would be pre-heated using residual heat from the sodium diuranate (SDU) thickening stage before mixing with some of the thickened SDU slurry to ensure the PLS uranium grade was consistent. The resultant slurry would be mixed with sodium hydroxide to precipitate SDU. The SDU thickener would separate the precipitated solids from the barren solution. The solids would be thickened. The barren solution would be cleaned by a series of sand filters before being recarbonated using exhaust gases from the power station generators and boilers and recycled to the CCD circuit as a wash solution.

6.4.2.5 Sodium Diuranate Refining

The temperature of the thickened SDU slurry would be lowered and its pH lowered through contact with sulphuric acid, to dissolve the uranium and vanadium from the precipitated SDU slurry into a solution. This solution would then be transferred by gravity to a series of tanks, where the temperature would be raised to precipitate out some of the vanadium and leave most of the uranium in solution. The uranium-rich liquor would be directed to the uranium precipitation stage and the vanadium-rich slurry would be filtered, repulped with water and mixed with sodium hydroxide. This causes the remaining uranium within the slurry to dissolve and then precipitate out (as SDU), leaving the vanadium, which also dissolves but does not precipitate, to be filtered and subsequently pumped to the TSF. The filter solids, containing residual uranium, would be returned to the SDU thickener.

6.4.2.6 Uranium Precipitation and Packing

The uranium-rich solution generated from the SDU refining stage would be cooled and mixed with sodium hydroxide and hydrogen peroxide, resulting in the precipitation of uranium peroxide. The resultant slurry would be thickened and the solids separated from the solution.

The solids would be directed to a uranium storage tank before dewatering and packing, and the solution pumped back to the mill water tank would be used as make-up water in the milling circuit.

A centrifuge would be used to dewater the uranium slurry before drying, and an electrically heated indirect oil dryer would reduce the moisture content of the UOC to less than 1%. The dried product would be top-loaded into 205-litre steel drums and sealed with lids and ring- clamps. The drum-filling station would be located in an airlock that maintained negative pressure to prevent uranium entering the work areas. The outside of the drums would be subsequently washed to remove any residual product from the lids and surfaces before labelling and loading into shipping containers for transport and export.

6.5 Tailings Management

The tailings material discharged from the metallurgical plant following extraction of the uranium would be disposed of in previously mined voids within the proposed open pit. Approximately 36 Mt of tailings would be disposed to the open pit during the proposed life of the operation.

The in-pit tailings facility would comprise a series of cells constructed sequentially as the pit was mined. Each cell would be around 200,000 to 300,000 m^2 in area and would take about five to six years to fill to an average height of about 2 m below ground level (1 m at the crest, to 3 m at the decant pond). After filling, the cells would be allowed to consolidate for some time (estimated at around 1 year) before capping with previously mined material and topsoil. Up to 22 cells would be built within the pit void over the life of the operation, with 3 to 5 cells active at any one time. Cameco has undertaken a detailed study for the design and operational aspects of the TSF. The report is presented in Appendix D. A summary of the major features of the proposed tailings storage facility is provided in Table 6-5.

Table 6-5: Indicative features of the proposed tailings storage facility

Features	Proposed Development
Storage method	In-pit storage
Total disposal of tailings (Mt)	36
Average annual tailings production rate (Mtpa)	2.4
Number of TSF cells	Up to 22
Number of TSF cells active at any one time	3 to 5
Area of each TSF cells (m^2)	200,000 to 300,000
Years to fill each TSF cell	5 to 6
Average rate-of-rise of tailings (m/a)	1.2 to 1.4
Average solids concentration (%)	40

6.5.1 Tailings Properties

Indicative properties of the tailings are provided in Table 6-6. The geochemical and radiological properties of the tailings are described in Tables 6-7 to 6-10. As these have been derived from specific ore blends, the final tailings properties may differ.

Table 6-6: Indicative tailings material properties

Parameter	Value
Plasticity (LL[1])	59 to 71%
Plasticity (PL[2])	21 to 30%
Plasticity (PI[3])	38 to 41%
Particle specific gravity (SG)	2.61 to 2.8

Parameter	Value
Initial settled density	50 to 53% (dry density of 0.73 to 0.81 t/m^3)
Average dry density	1.2 to 1.4 t/m^3
Tailings permeability	1 x 10^{-9} m/sec
Beach slope	1%
Coefficient of consolidation	1 to16 m^2/a
Shear strength (Su/σv)	0.29
Rheology yield shear stress	20 N/m^2
Plastic viscosity	0.014 N/m^2/sec

[1] Liquid limit.
[2] Plastic limit.
[3] Plasticity index.

Table 6-7: Indicative geochemical constituents of tailings solids

Constituent	Unit	Concentration
Aluminium	wt%	3.8
Antimony	ppm	<0.5
Arsenic	ppm	14
Calcium	wt%	10.6
Carbon	wt%	5.6
Copper	ppm	18
Iron	wt%	1.8
Lead	ppm	130
Magnesium	wt%	4.2
Molybdenum	ppm	27
Potassium	ppm	7,480
Selenium	ppm	0.2
Silicon	wt%	20.9
Sodium	ppm	40
Uranium	ppm	150
Vanadium	ppm	260

Table 6-8: Indicative geochemical constituents of tailings liquor (µg/L unless indicated)

Constituent	Concentration	Constituent	Concentration
pH	9.6 to 9.7	Cadmium	<5
Total alkalinity	75,300 mg $CaCO_3$/L	Cobalt	<5
Aluminium	780	Chromium	350
Calcium	500	Copper	80

Constituent	Concentration	Constituent	Concentration
Iron	450	Mercury	<0.1
Potassium	1,590,000	Lithium	6
Magnesium	350	Manganese	<5
Sodium	44,800,000	Molybdenum	2,400
Silicon	13,000	Nickel	<5
Bromine	43,000	Phosphorus	<100
Chlorine	15,000,000	Lead	<5
Fluoride	<500	Antimony	<5
Nitrate	610,000	Selenium	490
Sulfate	8,800,000	Tin	10
Silver	<5	Strontium	60
Arsenic	7,900	Titanium	<5
Boron	30,000	Uranium	50,000 to 100,000
Barium	10	Vanadium	35,000
Beryllium	<5	Zinc	130
Bismuth	<5	Salinity	>15,000 mg/L TDS

Table 6-9: Indicative radiological constituents of tailings solids

Radionuclide	Activity (Bq/kg)
Uranium-238	940 to1,140
Thorium-230	9,540 to 17,800
Radium-226	9,220 to 14,300
Lead-210	10,200 to 15,700
Polonium-210	n/a
Uranium-235	<40 to 110
Actinium-227	390 to 610
Thorium-232	n/a
Radium-228	47 to 120
Thorium-228	47 to 79
Potassium-40	290 to 470

Table 6-10: Indicative radiological constituents of tailings liquor

Radionuclide	Activity (Bq/L)
Uranium-238	2,190 to 4,840
Thorium-230	<110 to 450
Radium-226	13 to 67
Lead-210	<7 to 37
Polonium-210	n/a
Uranium-235	110 to 220
Actinium-227	<2 to 4.1
Thorium-232	<4
Radionuclide	Activity (Bq/L)
Radium-228	<1
Thorium-228	<0.5 to1.5
Potassium-40	42 to 48

Design Intent

The proposed TSF has been designed to provide safe and economic permanent storage of tailings in a way that minimises potential environmental impacts and risks. The intent of the closure design is to provide an erosion-resistant and non-polluting facility that is stable in the long term. In addition, the proposed TSF design aims to:

- minimise the overall project disturbance footprint;
- maximise the volume of tailings liquor and water than can be reclaimed to the metallurgical plant; and
- minimise the volume of seepage.

To meet the design intent, the proposed facility design has been based on standards and guidelines set by the Australian National Committee on Large Dams (ANCOLD) and the Western Australian DMP. The major design and operational aspects considered during the design of the TSF were:

- TSF location and layout;
- hydrological and hydraulic factors;
- geotechnical, geochemical (geomorphological) and radiological factors;
- availability and properties of construction materials;
- embankment design and stability;
- operational factors; and
- post-closure land use and landform.

6.5.2 TSF Location and Layout

Tailings from the metallurgical plant would be discharged to a series of cells created within the open pit void following mining. Each mining block (see Section 6.3.2 for further information) would be converted for use as TSF cells following the completion of mining within that block. Each block would nominally be divided into one to three TSF cells, depending on the size of the mined block, with a target TSF cell area of about 200,000 to 300,000 m^2. Figure 6-12 shows the proposed metallurgical process flow diagram and Figure 6-13 illustrates the overall TSF cell layout, with an inset showing a conceptual plan and elevation view of an individual TSF cell.

To avoid the need for an initial external (above-ground) TSF cell, mining Block #1 and part of mining Block #2 would be excavated and stockpiled prior to the commencement of processing, to permit in-pit disposal of tailings from the commencement of metallurgical operations.

6.5.3 Hydrological and Hydraulic Factors

6.5.3.1 Surface Water Management

The design of the TSF would include establishing embankments (designed as water-retaining structures constructed with clay material from the bottom of the open pit) to safely separate the active mining areas and the pit wall from the tailings (see Figure 6-13). The drain between the pit wall and the TSF embankment would help direct any groundwater or surface water inflow to the pit dewatering system. At closure, the area between the pit wall and the TSF cell embankment would be backfilled with a higher-permeability material sourced from waste rock to allow it to continue to function as a higher groundwater flow zone post-closure (and thus avoid groundwater flows through the tailings material).

6.5.3.2 Freeboard

The internal TSF cell embankments, and embankments separating the TSF from active mining areas, constructed of either consolidated tailings or compacted clay would be built to a height of around 1 m below ground level. The cell would be filled with tailings so the tailings surface was an average of about 2 m below the original ground level. The beach freeboard, the basin formed by the tailings beach and the storage capacity provided by unfilled tailings cells (as the embankments are constructed to full height), would ensure there was sufficient freeboard and storage capacity at all times to contain a probable maximum precipitation (PMP) event.

6.5.4 Geotechnical, Geochemical and Radiological Factors

6.5.4.1 Tailings Characterisation

Golder Associates (1982) investigated and characterised the proposed Yeelirrie tailings through laboratory testing and studies on an experimental tailings pond and two tanks of tailings at the Kalgoorlie-Boulder Research Station. Further laboratory testing and analysis has been conducted as part of studies undertaken to support the PER.

6.5.4.2 Construction Materials

TSF embankments close to the pit walls would be constructed of clay-based materials originating from the development of the pit. Some materials from the on-site quarry may be required (e.g. for surfacing temporary roadways), subject to meeting the required construction material properties. TSF embankments that are not near the pit walls, including intra-cell embankments, would be constructed of either compacted clay or consolidated tailings.

6.5.4.3 Embankment Design and Stability

The proposed in-pit TSF embankment would be designed to meet or exceed the Australian National Committee on Large Dams (ANCOLD) Factor of Safety requirements (see Table 6-11) using the seismic coefficients stability criteria as listed in Table 6-12. The high pool case assumes that water is ponded against the embankment and the embankments are designed as water-retaining structures.

Table 6-11: Factor of safety for the proposed in-pit TSF cells

Loading condition	Factor of safety
Normal operation	1.5
Steady state seepage (high pool)	1.3
Earthquake	1.1

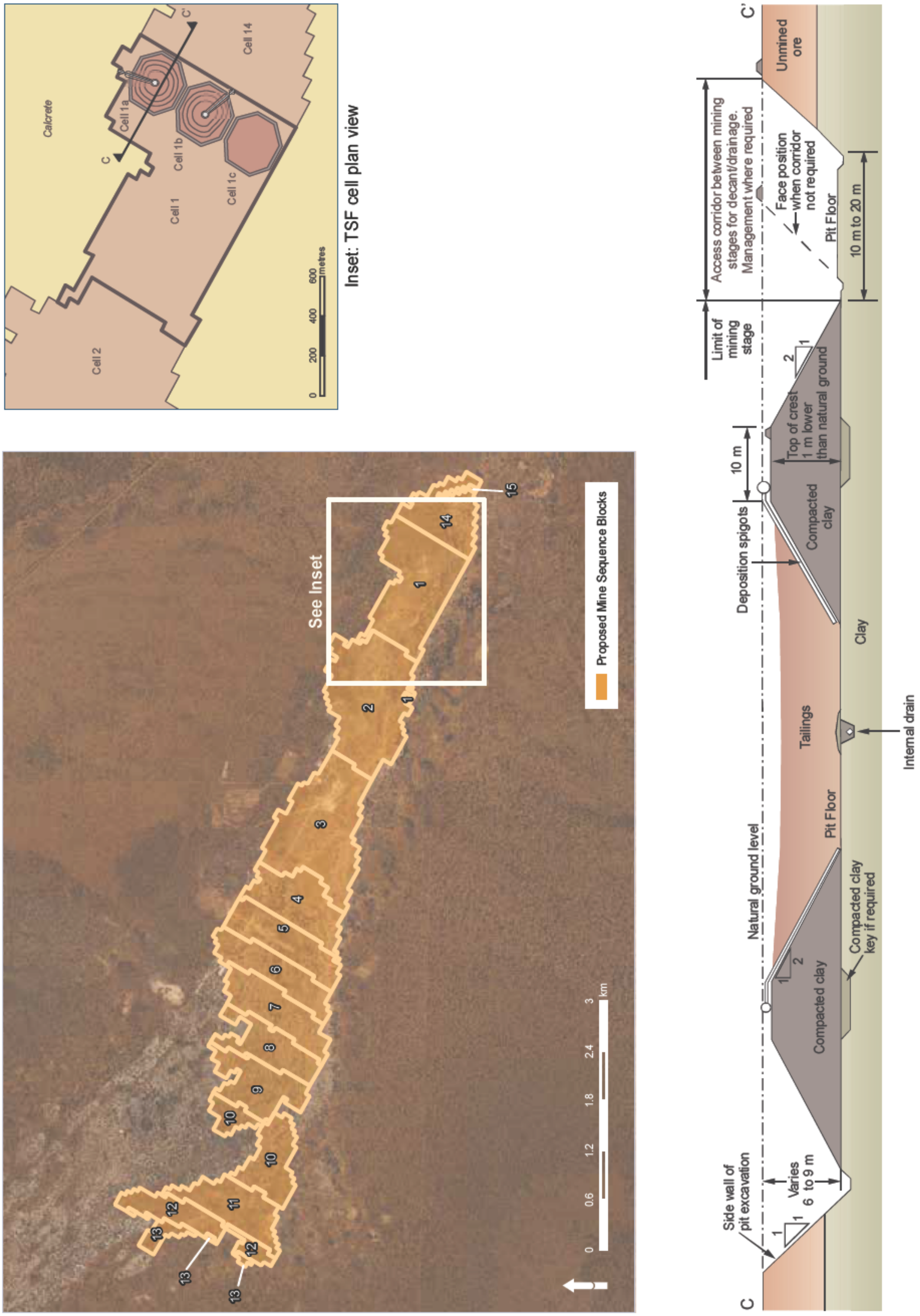


Figure 6-13: Conceptual tailings storage facility cell layout

Table 6-12: Seismic coefficients for the proposed TSF design

Earthquake	Return period	Pseudostatic seismic coefficient
Operating basis earthquake (OBE)	1,000 years	0.036
Design basis earthquake (DBE)	5,000 years	0.06
Maximum credible earthquake (MCE)	>10,000 years	0.13

Operational Factors

6.5.4.4 Tailings Construction and Commissioning

Mining Block #1 and part of mining Block #2 would be mined to allow for the disposal of tailings from the metallurgical plant following commissioning. After the pit was established, an embankment would be constructed along the proposed TSF cell internal perimeter wall to a height about 1 m lower than the natural ground level. Embankments would separate the active TSF cells from the active mining works, the open pit walls and the previously filled TSF cells to assist with water management and ensure TSF cell stability. Before deposition, each TSF cell would be prepared by ensuring there were no defects in the clay floor materials, and the embankment foundations would be constructed down to the low-permeability materials making up the cell floor.

Deposition infrastructure in the form of a tailings pipeline would encircle the TSF cell, and deposition spigots would be installed down into the cell to allow for tailings dispersion near the tailings surface to minimise the potential for erosion of the beach. Approximately three to five TSF cells would be constructed and operated initially, with additional cells constructed as required and as pit voids became available and operating TSF cells were filled to design.

The TSF cells are underlain by up to 60 m of very low-permeability clay, which would reduce the potential for seepage. The TSF start-up plan would minimise the ponding of water on bare ground by capturing and returning free water to the metallurgical plant. The TSF schedule allows for the early start-up of each cell to establish a consolidated tailings layer that would effectively act as a low-permeability liner. The permeability of the pit floor and the TSF cell embankments would be very low, with an estimated permeability of 1×10^{-9} m/sec, similar to the permeability of a geosynthetic liner.

Additionally, the underdrains established to dewater the pit floor before mining may be used as underdrainage within each cell to help collect and return leachate to the metallurgical plant. Initial trials in the early cells may show that the very low permeability of the consolidated and dewatered tailings may reduce seepage to the extent that the underdrains did not collect any leachate, in which case they would not continue to be used in later cells. Seepage from the TSF has been modelled and the results and discussion is presented in Section 9.5.

The average rate-of-rise of the TSF cells to efficiently dry the tailings and minimise seepage would be around 1.2 to 1.4 m a year. Each cell would take between five and six years to fill, to a maximum height of around 2 to 3 m below ground level before the deposition of tailings ceased (see Figure 6-13). The ‘bowl’ of the cell may be filled using central decant techniques before decommissioning of the cell. Tailings would be allowed to consolidate for around one year before the start of closure and rehabilitation activities (see Section 6.13).

6.5.4.5 Tailings Discharge, Reclaim and Surface Water Management

Layers of tailings would be deposited via a peripheral header, with spigots placed about 25 m apart. Tailings would be deposited around the facility in thin layers of around 100 mm, allowing approximately 30 days drying between each layer. The thin-layer deposition would promote evaporation of tailings liquors and increase the rate of consolidation and strength of the tailings. Excess liquor would pond at the centre of each TSF cell and be reclaimed through a central decant system.

Reclaimed liquor and stormwater would be pumped to the metallurgical plant for reuse as raw water make-up. Maximising the collection of water within each TSF cell for return to the metallurgical plant would reduce the head pressure that may otherwise encourage seepage in the central decant area. During operation, the tailings surface would be kept moist by the thin-layer deposition to minimise radon exhalation.

Very little seepage from the TSF is anticipated because of the proposed tailings drying cycle, which locks the solutes into the tailings matrix. As discussed above, underdrainage would initially be established within each TSF cell as a precautionary measure to help collect and return leachate to the metallurgical plant. The TSF cells would be covered (capped) as soon as possible after filling to prevent rainfall and stormwater infiltration.

6.5.4.6 Evaporation Pond

Under some circumstances there will be excess water in the site water balance. For example, not all of the reclaimed tailings liquor will be able to be reused in processing, and in other scenarios it may be necessary to store storm water captured within the disturbed area. Water from these sources would be stored and evaporated from the proposed Evaporation Pond. Water balance modelling has determined that a pond of approximately 50 hectares and up to 5 m deep would be required to store and evaporate water. The pond is likely to be constructed with multiple cells to provide the opportunity for the removal of sediment and evaporites. In order to maintain the effectiveness of the evaporation dam, the cells will require routine cleaning which would involve removal of sludge and sediment. The removed material will be placed into the TSF.

While there are a number of surface water bodies (salt lakes and claypans that fill and hold water for extended periods after rain) in the north eastern goldfields region, the presence of a large permanent water body is likely to attract some bird and animal life. The design, construction and operation of the facility will be aimed at reducing the attractiveness of the facility to fauna. The internal and external wall slopes will be steep to remove the potential for beaches to form and the facility would be fenced to exclude native and feral fauna. Bird scare devices such as rotating beacons with intermittent beams and noise generating gas guns would also be installed if necessary.

Cameco has modelled the quality of the water being stored in the facility, which will change over time as water of differing quality is added to the dam, to understand the potential impact on birds that might land on and consume the water. These results and a discussion is presented in Section 9.3.5.2.

6.6 Water Demand and Supply

The proposed development would require water of varying quality for different uses during both the construction and operational phases, the most significant of which would be non-potable saline water for use within the processing plant and for dust suppression associated with the mining operation. The construction of infrastructure associated with the proposed development would also require water, specifically for use in compaction activities, concrete manufacture, dust suppression and water-testing of pipelines and water supply infrastructure.

Where possible, saline water would be used to reduce the demand for better-quality water. In general, better-quality water (less than 10,000 mg/L total dissolved solids (TDS)) will be used as feed water for the reverse osmosis (RO) desalination plant (see Section 6.6.3 for details). Average quality water (between about 10,000 to 30,000 mg/L TDS) would be used within the majority of the metallurgical processes. Lower-quality water (greater than about 30,000 mg/L TDS) would be used to suppress dust.

A summary of the water demand and supply source for the construction and operation of the proposed development is presented in Table 6-13. The total annualised average operational raw

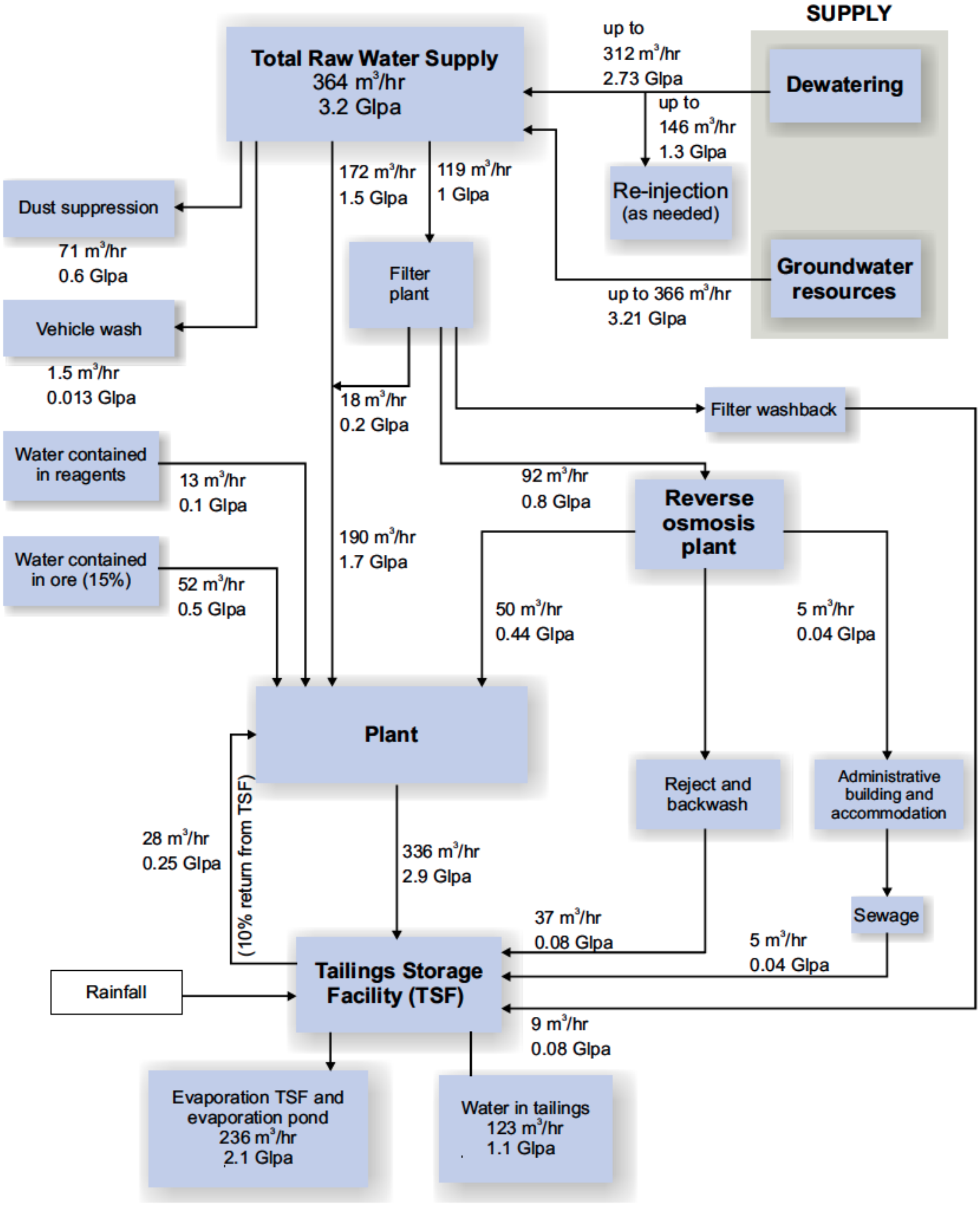


Figure 6-14: Conceptual water balance

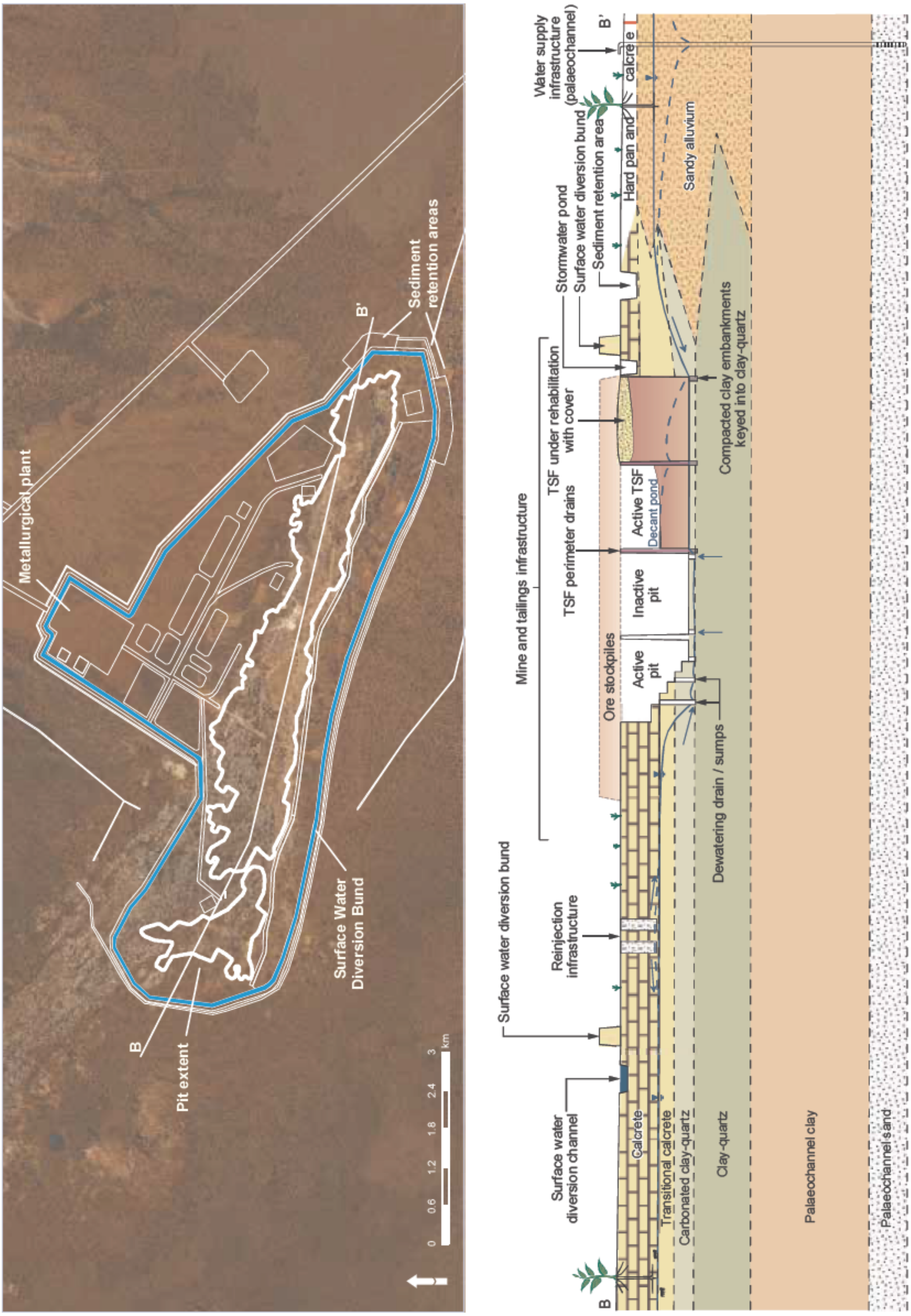


Figure 6-15: Conceptual open pit dewatering cross-section

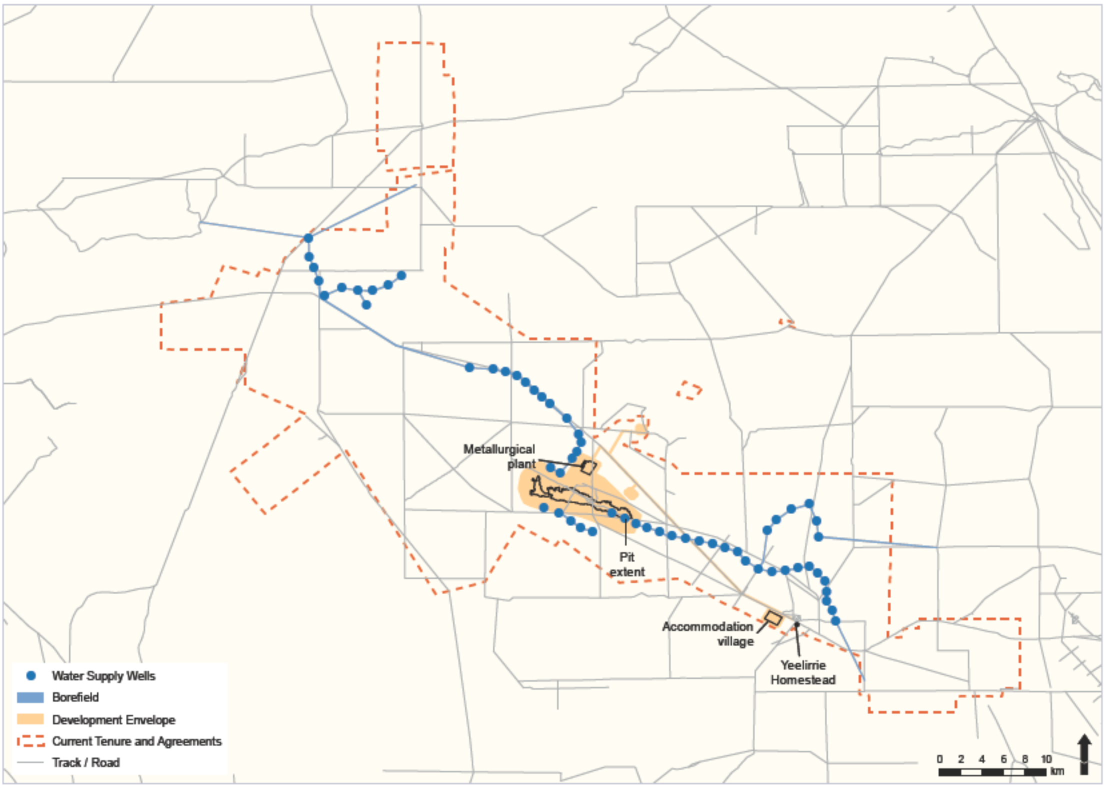


Figure 6-16: Indicative Yeelirrie wellfield infrastructure layout

water demand during the period when mining and processing are both in operation is estimated at around 8.7 ML/d.

Table 6-13: Indicative water demand for the proposed development

Demand Ml/d	Use
4.8	In the metallurgical plant for the treatment of ore
2.2	Reverse Osmosis plant for use on-site as drinking water in the accommodation village and administration facilities and in the boiler for steam production.
1.7	Dust suppression within the open pit mining operations
0.03	Vehicle washdown

A conceptual water balance for the proposed development is illustrated in Figure 6-14.

The following sections outline the proposed water supply infrastructure.

6.6.1 Water supply

6.6.1.1 Pit Dewatering Supply

The proposed open pit would be up to 15 m deep and would intersect the groundwater table, which occurs 3.5 to 5 m below the surface. To facilitate the mining operation, the open pit would be dewatered to control inflows of groundwater and to reduce the amount of water on the active pit floor to provide a safe working environment.

To facilitate dewatering, a system of slots, trenches or wells that intersect the groundwater would be excavated in advance of the active mining areas. The low-quality water collected in the slots or trenches would be directed to a series of sumps, from where it would be pumped to a water storage pond before use within the metallurgical plant, or for dust suppression activities within the open pit and surrounding stockpiles (see Figure 6-15). The initial rates of groundwater extraction from mine dewatering could be up to about 7.5 ML/d in year 4, decreasing over the life of the proposed mining operation to approximately 2 to 3 ML/d from years 5 to 18 as groundwater levels within the mine footprint decrease.

A series of mobile transfer pumps would be established within the open pit to manage rainfall that fell directly into the pit. Once the surface water diversion bund had been established, stormwater that accumulated within the flood protection bund during rainfall events would be directed to water storage infrastructure or the pit for temporary storage. The proposed facility would be managed as far as practicable to segregate and separately manage stormwater falling within the flood protection bund, depending on both its quantity and quality for use on site.

It is expected that pit dewatering would form the primary water supply for the proposed development for the first 4 years, after which production from a borefield would be required to supplement operational demand.

6.6.1.2 Wellfield Supply

Water supply infrastructure would be constructed, linking the development to a series of wellfields located near the Ministerial Temporary Reserve and within the defined Project Area (see Figure 6-16).

The Yeelirrie Wellfield would be developed with the capacity to supply the entire water demand of the proposed Yeelirrie development, providing a supply network with redundant (i.e. additional) capacity.

In planning the water supply to meet the required demand, Cameco's philosophy has been to target more saline sources, to minimise the demand on sources of better quality water. The additional capacity confirmed through modelling provides Cameco with some flexibility to manage extraction from each source to meet environmental aspects.

Dust suppression water would continue to be supplied via pit dewatering. The infrastructure for the Wellfield would include electrically pumped wells connected to the metallurgical plant via a buried pipe.

Power would be supplied to each well via an overhead line from the generators. Tracks would be established to provide access to the wells and the pipeline and power corridor. The water supply pipeline would pass beneath public roads surrounding the Project Area, with road crossings kept to a minimum.

6.6.2 Water Treatment

The proposed development would require water of various qualities to be generated from the raw water obtained from the primary supply (either pit dewatering or the saline Wellfield supply). To facilitate this, two package water treatment plants would be installed on-site.

6.6.2.1 Reverse Osmosis (RO) Desalination Plant

The proposed RO unit would treat about 2 ML/d of raw water from the wellfield, to produce about 1 ML/d of RO water and 0.1 ML/d of potable water from feed water containing less than 10,000 mg/L TDS. The RO water would be used within the metallurgical plant in the leaching and precipitation stages and the 0.1 ML/d of potable water would be further treated before use within the administration and village facilities (see Section 6.12).

The RO unit would generate about 1 ML/d of brine and filter backwash solution containing residual quantities of coagulants and other conditioning chemicals. The reject stream would be directed to the TSF.

6.6.2.2 Potable Water Treatment

The potable water generated by the RO plant would be further treated in a package water treatment plant to produce drinking-quality (potable) water. The treatment would consist of calcite filtration and chlorination. There is expected to be little, if any, waste associated with the operation of this water treatment plant. The plant would be used to meet the demand for potable water within the on-site administration infrastructure and the accommodation village.

6.6.3 Water Recycling

Extensive water reuse and recycling systems would be developed for the proposed development to minimise the demand for raw water from the local and regional systems. Examples include:

- directing most wastewater streams to the metallurgical plant grinding circuit;
- recirculating and treating liquors within the metallurgical plant, in particular the precipitation stages, to both reduce raw and RO water demand and ensure the recovery of a greater proportion of the contained uranium;
- capturing stormwater within mining-disturbed areas and treating and using it in place of groundwater, reducing groundwater abstractions and also reducing the energy necessary to operate the RO plant as a result of the higher quality of stormwater over groundwater; and
- the extensive use of heat exchangers to reuse the heat capacity of some of the precipitation stages to reduce the steam (hence water) demand in other stages.

6.7 Site Infrastructure

A range of site infrastructure would be required to support the proposed mine and metallurgical plant, including the following:

- accommodation village;
- quarry;
- internal access roads;
- metallurgical plant and associated infrastructure in preparation for processing;
- mine infrastructure in preparation for the mining development;
- installation of pit dewatering infrastructure;
- water management infrastructure;
- an administration building;
- operations stores and warehouse facilities;
- maintenance workshops;
- sand blasting and painting facilities, including a decontamination area for the removal of surface radiation before clearance from site;
- laundry and employee change and washing facilities;
- a sewage treatment plant;
- a process control room;
- security and emergency response facilities, including the provision of a fire tender and ambulance; and
- a vehicle wash-down, drive-through vehicle wheel wash and weighbridge facility fitted with sediment capture and oil separators.

These infrastructure elements would be constructed and operating before the metallurgical plant was commissioned.

6.7.1 Site Security

A number of levels of site security would be provided:

- The mining area would be fenced with a ring lock fence.
- The process facilities and mine workshops would have secured area barrier fencing with primary access via a security gate with swipe card entry.
- The packaging and drying facility would be a fully monitored and secured area within the process area, with restricted swipe card entry.

6.8 Energy Supply

The current Project design is based on a diesel fired power station. An alternate option under consideration would use a gas fired power station, subject to finalising the availability of gas and viability of that option. The gas fired option may bring minor environmental benefits but would require a gas supply pipeline (approximately 50 km long) to be installed. The viability of the gas line extension and the impact on other gas users in the region is currently under review. Should the gas fired power plant become the preferred option, separate approval would be sought for the construction of the gas pipeline.

Based on an assumption to implement the diesel fired power station as the base case, most of the energy demand for the proposed development will be associated with diesel-fired electricity generators, diesel-fired steam generation and diesel-fuelled heavy and light vehicles. The estimated demand for diesel and electricity is summarised in Table 6-14 and detailed in the following sections.

Table 6-14: Indicative energy demand for the Project

Energy source	Proposed annual demand (kL/a)
Diesel – on-site vehicles	6190
Peak/average diesel – materials transport	24,000/4,000
Diesel – electricity generation	34,000
Diesel – steam generation	28,000
Electricity[1]	150,000 MWh/a

Notes:

[1] Electricity demand is internal to the site. Demand is met through the on-site generation of electricity from diesel and no external connections are required

6.8.1 Vehicle Fleet Diesel

Approximately 6,190 kL/a of diesel would be required to operate the heavy and light vehicles associated with the proposed development; most of this fuel would be used to supply the heavy vehicle mining fleet. A fuel unloading and storage facility complying with the relevant Australian Standards would be constructed close to the proposed vehicle maintenance area and the steam and electricity generators to minimise the length of pipework. This facility would provide dispensing facilities for heavy and light vehicles. A conventional mains fire protection system, using RO water, would be installed in accordance with relevant standards and legislation.

6.8.2 Electricity Generation

The peak electricity demand for the proposed development would be around 20 MW to meet an average annual consumption of around 150,000 MWh. Most of this power would be required to operate the grinding mill and pump process slurries within the metallurgical plant.

The electricity requirements would be met by installing a series of diesel fired electricity generators (or an alternate gas fired option) and local electricity transmission infrastructure. Installing multiple generators would provide contingency in the event of planned and unplanned generator outages and also allow the operation of the generators to be optimised, minimising power station fuel consumption.

Exhaust gases from the diesel generators would pass through a waste heat boiler to supplement the steam supply, and then be directed into the barren solution stage of the metallurgical process, where some of the carbon dioxide would recarbonate the solution before it was used as a wash solution within the CCD stage of the metallurgical process.

6.8.3 Steam Generation

A diesel fired steam generator (or co-generation from a gas fired power station) would be installed, with sufficient capacity to provide about 25 tonnes per hour (t/h) of high-grade steam at a pressure of around 1,000 kPa. A boiler would also be constructed to capture waste heat associated with the exhaust gases of both the electrical generators and the steam generators.

The requirement for steam generation would be minimised through the use of heat exchangers within the metallurgical process to transfer heat between process streams, where significant differences in heat are demanded by the nature of the precipitation process.

6.9 Chemical Storage and Use

Table 6-15 lists the indicative volumes of reagents and methods of storage that would be required for the proposed development. The nominal reagent site storage capacity has been set at five to ten days, but this is subject to identifying suppliers and agreeing to supply arrangements, which would be determined during detailed design.

Table 6-15: Indicative annual metallurgical plant requirements and storage methods

Bulk chemicals and reagents	Annual consumption (tpa)	Storage method
Sodium hydroxide (liquid 50% w/w)	200,000	Bunded storage tank
Sodium carbonate (dry, bulk dense)	15,500	Bunded storage tank
Sodium bicarbonate (dry, general purpose)	9,500	Bunded reagents area, stored in the as-transported bulk bags (1,000 kg each)
Sulphuric acid (liquid, 98% w/w)	4,500	Bunded storage tank
Hydrogen peroxide (liquid, 70% w/w)	2,000	Bunded storage tank
Flocculants and coagulants (liquid, bulk)	1,200	Flocculent is stored in the as-transported bulk bags. Coagulant is stored in the as-transported standard liquid containers. Both are stored within the bunded reagents area
Operating consumables	**Annual consumption (tpa)**	**Storage method**
Grinding media	660 t	Stored in a hardstand area near the milling circuit. Mill lubricants including oils and greases would be stored in a bunded hydrocarbon area
Mill liners	2 sets	
Mill lubricants	50 drums	
Wedge wire screen	32 panels	
Filtration media	1 change every three years	
Final product drums	33,000 drums	

6.10 General Waste Management

Due to the isolated nature of the site and the absence of waste management infrastructure, Project-specific waste recycling, treatment and/or disposal facilities would be required for the construction, operation and decommissioning phases. Although the volumes are likely to vary from phase to phase, general wastes arising from the development can be broadly categorised into four types, as set out below:

- non-process solids wastes;
- non-process liquid wastes;
- low-level radioactive wastes; and
- controlled wastes.

Each of these categories is discussed in greater detail in the following section. The waste types discussed exclude mined materials, tailings and process water, which have been previously discussed.

6.10.1 Waste Management Facility

The primary segregation and management of non-process wastes would be undertaken within a waste management facility constructed to the east of the metallurgical plant (refer Figure 6.3), on a fully fenced and gated area of around 15 ha. This facility would be operated for the life-of- mine, at the predicted waste generation rates outlined in the following paragraphs. The waste management facility would consist of:

- collection bays for the temporary stockpiling of waste streams pending transport off-site to third-party treatment and disposal facilities;
- a transfer station for the segregation of waste materials;
- a category 89 putrescible and clinical waste landfill, which would not intercept the water table and would not exceed a final height of 1.5 m above surrounding grade (category as per WA Department of Environment and Conservation (DEC) Landfill Waste Classification and Waste Definitions 1996 (as amended December 2009)); and
- a general inert cover material laydown area (buffer zone), including firebreak.

Cover would be provided on a monthly basis, with the waste cells constructed according to the DER guidelines for landfills.

6.10.1.1 Non-process Solid Wastes

Non-process solid wastes that would be generated by the proposed development include reagent and spare parts (consumables) packaging, construction and maintenance wastes and general office and administration wastes such as cardboard, paper, plastics, timber and concrete.

6.10.1.2 Non-process Liquid Wastes

Non-process liquid wastes, including vehicle wash-down water (following oil/water separation), stormwater and desalination brine, would be collected and directed to the TSF for reclaiming and reuse within the metallurgical process or as needed for dust mitigation.

Water associated with the generation of sewage wastes would be treated in one of two package wastewater treatment plants (one for the site office, and a larger facility for the proposed accommodation village) with sufficient capacity to accommodate the staffing numbers. After leaving the treatment plants, the water would be used for dust suppression or general site irrigation or removed from site by licensed operators.

6.10.1.3 Low-level Radioactive Wastes

Small quantities of low-level radioactive wastes (LLRW) would be produced by the proposed development. These would comprise laboratory wastes (about 4 to 6 m^3/a) and used personal protective equipment (about 20 m^3/a). In addition, some used items of plant and equipment that were found not to meet the radiation activity criteria for off-site disposal would be stored within the site boundary in a suitable facility before disposal. LLRW material would ultimately be disposed of within the TSF cells in discrete campaigns – typically, in excavated trenches which would be immediately backfilled.

Radiation source equipment would be used on-site including wellhole logging (Cf-252), automatic weighing and gauging equipment (Ce-144) and smoke detectors (Am-241). Radiation source equipment would be returned to the supplier at the end of its productive service.

6.10.1.4 Controlled Wastes

Controlled wastes are waste materials as defined in Schedule 1 of the Environmental Protection (Controlled Waste) Regulations 2004. Some controlled wastes for which there are no favourable recycling option would be collected and forwarded to off-site licensed facilities for treatment and disposal. The management practices for the controlled wastes arising from the proposed development are summarised in Table 6-16.

Table 6-16: Indicative controlled waste generation rates and proposed management

Waste type	Indicative management practice	Generation rate (tpa)
Chemical drums/aerosols/cans	Rinse and recycled	45
Oily rags/absorbents	Bagged and sent to third-party service provider	1
Diesel ash	Encapsulate or inert landfill disposal on site	5
Waste oil/solvents/coolants	Forwarded to third-party service provider for recycling	28
Tyres	Stockpiled and disposed in tailings or mine void	14
Batteries	Forwarded to third party service provider for recycling	10
Conveyor belt rubber	Disposed of in tailings or mine void	20
Fluorescent globes	Disposed of in tailings or mine void	0.25
Reagent bags	Disposed of in tailings or mine void	0.1
Kitchen oil/grease	Forwarded to third party service provider for recycling	10
Paint	On-site evaporation pad	3
Hydrocarbon contaminated soil	Treatment in bioremediation land farm	1
Reagent delivery/transfer hoses	Rinse and disposed in tailings or mine void	5
Total		142

6.11 Transport

The construction and operation of the proposed development would necessitate materials being transported to and from Yeelirrie. The logistics associated with this requires different strategies during the construction and operational phases of the Project (see Figure 6-17). The transport and logistics operation would comply with all relevant state and Australian transport requirements.

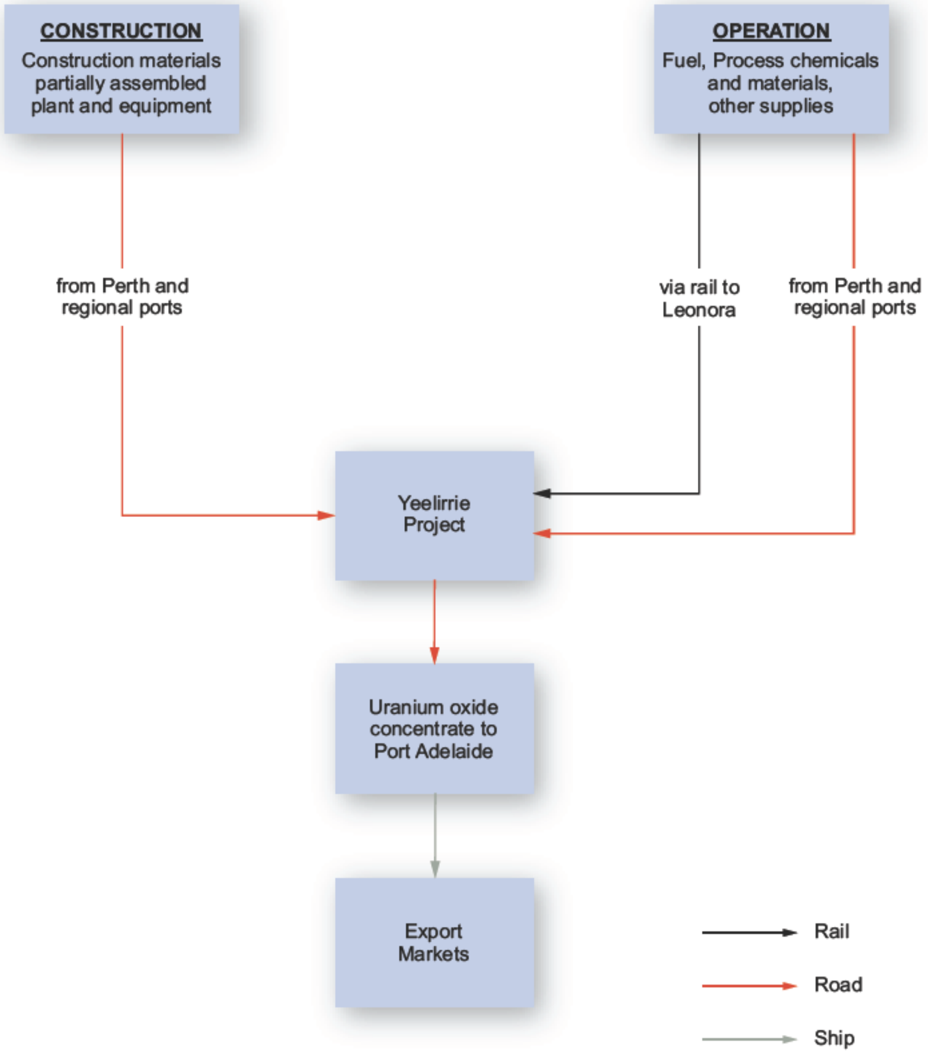


Figure 6-17: Indicative transport and logistics flow diagram

6.11.1 Site Access

As part of the early construction activities, a site access road would be built to connect the quarry to the metallurgical plant, crossing the existing Yeelirrie – Meekatharra Road (see Figure 6-18).

The main access to the proposed development would be from the Goldfields Highway, along the existing Albion Downs – Yeelirrie Road to the accommodation village (see Figure 6-18). Traffic between the village and the metallurgical plant would travel via the existing Yeelirrie - Meekatharra Road and would enter the site through a main gate to be established at the entrance to the metallurgical plant.

Some upgrading and modification of the existing road infrastructure would be required to enable heavy vehicle (e.g. triple road train) use and to minimise the risk associated with additional heavy vehicle traffic. These upgrades and modifications include:

- modification of road alignments to improve vehicle line-of-sight issues;
- upgrading of the Goldfields Highway and Albion Downs – Yeelirrie Road intersection with slip lanes and turning lanes to facilitate heavy vehicle movements;
- redesigning of some cattle grids;
- upgrading of the existing road dips;

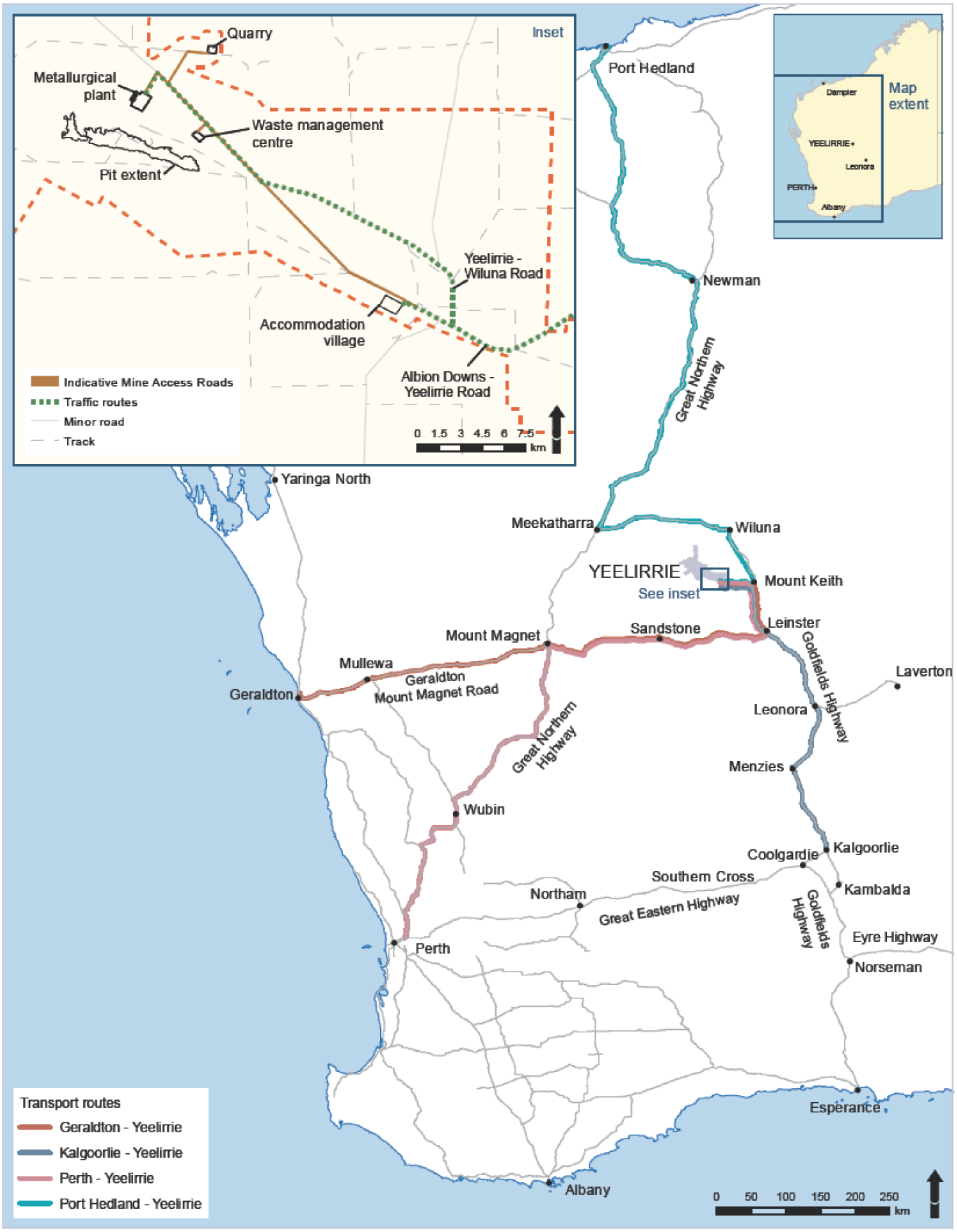


Figure 6-18: Transport and logistics

- the addition of an inspection bay to ensure that heavy vehicles transitioning from unpaved to paved road surfaces did not introduce debris to the roadways; and
- upgrading of existing road signs and installing additional signs where required.

Cameco would work with Main Roads Western Australia and the local shires of Leonora and Wiluna to facilitate the delivery of a regular and ongoing road maintenance program.

6.11.2 Construction Phase

The major construction, mining and workforce estimates are summarised in Table 6-17.

Table 6-17: Major construction, mining and workforce transport estimate

Item	Unit	Quantity to be transported
Construction items	Freight tonnes	50,000
Cement	Tonnes	10,000
Construction steel	Tonnes	7,000
Village facilities	Freight tonnes	600
Workforce bus movements (from Mount Keith Airport)	Annual trips	520
Mining equipment fleet	Road deliveries from Perth	72

The majority of the on-site infrastructure would be constructed on-site, necessitating road movements for the delivery of construction materials including cement, steel, machinery, pipework, pumps and valves. Other indivisible loads, consisting of partially assembled mining equipment and pre-assembled and prefabricated materials, will also be trucked to site. The transport of materials to and from site during the two-year construction phase would use around 24,000 kL of diesel annually. It is anticipated that partially assembled mining equipment would originate from Perth and/or Kwinana, and pre-assembled and prefabricated materials would be delivered from Kalgoorlie-Boulder, Geraldton and/or Port Hedland (see Figure 6-18).

6.11.3 Operational Phase

Details of the diesel consumption and likely annual reagent use associated with the proposed development were provided in Table 6-14 and Table 6-15, respectively. The estimated total transport volume (covering inbound raw materials and consumables along with outbound finished goods for the ongoing production and operational phase) is 344,000 tpa. The transport of materials to and from site during the operational phase would use around 4,000 kL of diesel annually.

6.11.3.1 Import of Materials

During the operational phase, some imported materials and supplies would be transported by rail from Perth and/or the east coast to the existing West Kalgoorlie-Boulder intermodal terminal, before being transported to Yeelirrie by road; other materials would be transported solely by road (see Figure 6-18). Wherever feasible, the transport of materials and supplies by road would use double and triple road train vehicles due to their freight efficiency. The Yeelirrie State Agreement nominates the import of caustic soda and diesel through the port of Esperance, then transport via rail to Leonora followed by haulage by road from Leonora to Yeelirrie. The Project will retain the option to import these commodities through Esperance as nominated in the State Agreement. The final transport solution for caustic and diesel will be decided after detailed negotiations have been finalised with potential suppliers.

Figure 6-19: Proposed uranium oxide transport routes

6.11.3.2 Transport of Uranium Oxide Concentrate (UOC)

After processing the uranium ore into UOC, it would be securely stored on the mine site before being transported by road to the existing port facilities in South Australia for direct export. The transportation of UOC is regulated by State and Australian agencies in accordance with the Code of Practice for the Safe Transport of Radioactive Material (current edition 2009), published by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA). Cameco would adapt the extensive transport management systems, processes and procedures applied at its Canadian operations for the proposed Yeelirrie development. The packed drums of UOC would be sealed, braced and locked in shipping containers in preparation for transport to Adelaide.

Shipments of UOC would be transported from Yeelirrie along the Goldfields Highway to Norseman, along the Eyre Highway to Port Augusta and then the Princes Highway to Adelaide (see Figure 6-19). All consignments would have extensive safety, operational, emergency response and security arrangements in place.

6.12 Workforce and Accommodation

6.12.1 Workforce

The construction and operation of the proposed development would require the employment of a workforce of up to approximately 225 people.

The proposed operational workforce would operate on a rotating shift roster on a fly-in/fly-out (FIFO) basis. The workforce would fly into Mount Keith Airport (subject to availability) and travel by bus to the mine site. In addition, and as deemed necessary, a bus service would be provided between Wiluna and the mine site for workers residing in this area. Private vehicles would not be able to access the mine site, but there would be a small number of private vehicle parking spaces at the accommodation village.

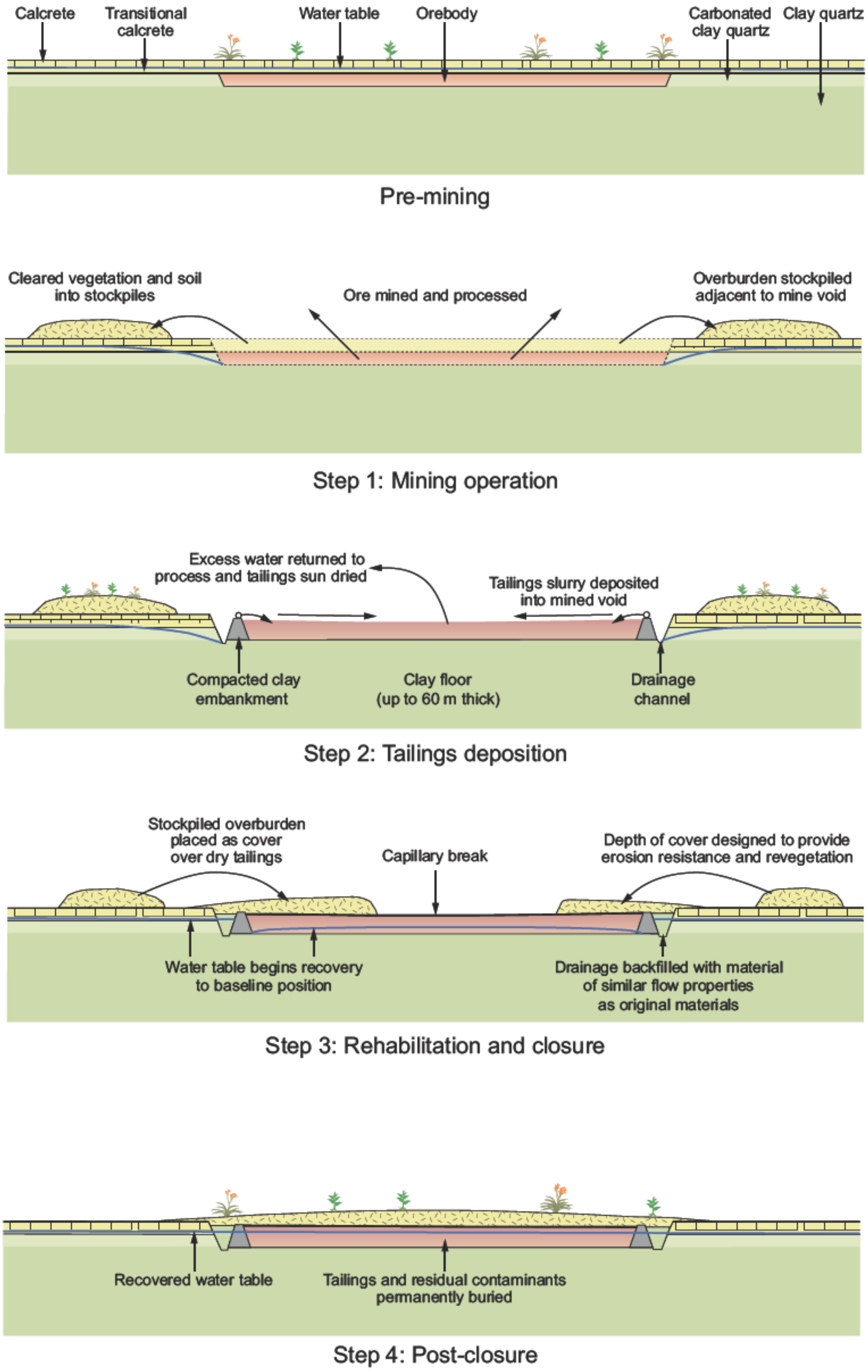


Figure 6-20: Conceptual final - post rehabilitation - landform cross-sections

6.12.2 Accommodation

An accommodation village would be established approximately 20 km south east of the metallurgical plant. At its peak, the facility would be designed to accommodate up to 1,200 people simultaneously, with separate accommodation areas for construction and operational phase workers. Following the completion of construction activities, a proportion of the accommodation units would be decommissioned and removed, subject to demand.

The accommodation units would comprise single-bed ensuite rooms, fitted with air-conditioners and refrigerators. Services at the village would include a laundry, gym, sports hall, mess facilities, a tavern and other entertainment infrastructure. Communications would be provided via a microwave link that connects into the national network, and the site would have mobile phone coverage.

The accommodation village would be supplied with electricity from generators, and with water from the on-site package water treatment plant. Sewage wastes would be treated in a package wastewater treatment plant.

6.13 Rehabilitation and Closure

6.13.1 Preliminary Closure Plan

A preliminary Mine Closure Plan for the proposed Project has been developed. The key objectives for the closure include:

- protecting the health and safety of the public and the workforce during closure activities and post-closure;
- minimising off-site impacts by controlling erosion and sedimentation and by minimising changes to background infiltration rates, and water levels and quality, upstream, downstream and close to the proposed development;
- returning the topography, soils, drainage and vegetation of disturbed areas, other than the TSF, to as close to pre-mining conditions as practicable;
- employing rehabilitation and closure methods to establish self-sustaining ecosystems that do not require ongoing maintenance;
- developing and implementing an appropriate post-closure monitoring and contingency plan to assess the performance of the closure and rehabilitation against agreed criteria; and
- developing a long term management plan for the Yeelirrie pastoral lease that ensures rehabilitation and conservation areas are protected from disturbances such as grazing.

An indicative flow diagram for rehabilitation and closure is presented in Figure 6-20. To achieve these outcomes, indicative closure methods have been developed for each of the key infrastructure elements. These are summarised in Table 6-18.

Table 6-18: Preliminary closure methodologies for key infrastructure elements

Infrastructure Element	Preliminary Closure Method
Open pit and associated infrastructure	Bury all tailings and materials that do not meet the surface activity criteria for off-site disposal (from other mine site areas and from stockpile footprints) in the pit void retained for this purpose. Back fill the mine void, first with low-level radioactivity waste material, followed by non-economic material. Rehabilitate the stockpile footprints and the various mine roads and infrastructure with the original surface cover material appropriately stockpiled during construction and mining operations. Revegetate with appropriate native plants. The cover to the mining area would be designed and constructed to be safe, stable and non-polluting. The cover would safely and securely contain the tailings and disposed infrastructure and minimise radiation exposure. Provide appropriate contouring and surface water management features to return mine-scale surface water flows to pre-mining systems, and locally to ensure that concentrated flow does not erode or damage rehabilitated areas. Where required, provide appropriate sediment catchment features to minimise sediment carry on to other areas. Divert groundwater flows around the contained tailings to minimise the release of contaminants into the groundwater.
Metallurgical plant	Demolish and remove all plant, structures, pipes, power lines and concrete footings down to a depth of at least 1.0 m below natural ground level. Remove all contaminated pipes and tanks. Recycle materials that are below contamination limits and dispose of the remainder in pits. Remove all contaminated soils and bury with all other contaminated material in the pit void reserved for this purpose. Dispose of all uncontaminated material by sale or in appropriate landfill. Remove pond liners and dispose of in pit. Demolish walls and either reuse embankment material for shaping and contouring or dispose of in pit. Rehabilitate entire area with the original surface cover material stripped and stockpiled during construction and operations, and revegetate with appropriate native plants. Provide appropriate contouring and surface water management features to ensure that concentrated flow does not erode or damage rehabilitated areas. Provide appropriate sediment capture features to minimise sediment carry on to other areas.

Infrastructure Element	Preliminary Closure Method
General infrastructure	Demolish and remove all plant, structures, pipes, power lines, and concrete footings down to a depth of at least 1.0 m below natural ground level. Remove all contaminated pipes and tanks buried at any level. Dispose of demolished and removed items in pit. Remove wellfield and surface water management infrastructure. Dispose of all uncontaminated material by sale or in appropriate landfill where it cannot be recycled. Remove all contaminated soils and bury with all other contaminated material in the pit void reserved for this purpose. Dispose of all uncontaminated material by sale or in appropriate landfill where it cannot be recycled. Rehabilitate entire area with the original surface cover material stripped and stockpiled during operations, and revegetate with appropriate native plants. Provide appropriate contouring and surface water management features to ensure that concentrated flow does not erode or damage rehabilitated areas. Provide appropriate sediment capture features to minimise sediment carry on to other areas.
Accommodation village	Remove all buildings and infrastructure and dispose of either by sale, or to an appropriate off-site landfill where it cannot be recycled, given that the accommodation village would not be contaminated, or in an appropriately constructed and rehabilitated on-site landfill. Remove all contaminated soils and bury with all other contaminated material in the pit void reserved for this purpose. Dispose of all uncontaminated material by sale or in appropriate landfill where it cannot be recycled. Rehabilitate the entire area with the original surface cover material stripped and stockpiled during construction and operations, and revegetate with appropriate native plants. Provide appropriate contouring and surface water management features to ensure that concentrated flow does not erode or damage rehabilitated areas. Provide appropriate sediment capture features to minimise sediment carry onto other areas.
Tailings storage facility	Following the completion of tailings deposition within a given cell, the tailings surface would dry, forming a salt-enhanced crust. After about one year after deposition ceased, the tailings cell would be covered with a 3 m layer of non-economic material and topsoil, minimising the release of radon, and would subsequently be allowed to revegetate. Higher-permeability materials would be used as backfill between the outer clay embankments and the open pit perimeter to act as a groundwater diversion channel to help exclude groundwater from the tailings mass, and maintain the long term integrity of the TSF cells.