# 1. Introduction

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## 1.1. Project

The Northern Territory Government (NTG; the Proponent), represented by the Department of Primary Industry and Resources (DPIR), proposes the rehabilitation of the former Rum Jungle Mine site (the project), located 6 km north of Batchelor, Northern Territory (NT). The project location and regional setting are shown on Figure 1-1. The purpose of the project is to restore water quality objectives within the East Branch of the Finniss River (EBFR) and improve onsite environmental conditions to support future land use as described in the Land Use Plan (see Figure 6-8 or Figure 7-2).

The Proponent submitted a Notice of Intent for the project to the Northern Territory Environment Protection Authority (NT EPA) on 30 June 2016 for consideration under the *Environmental Assessment Act 1982* (EA Act). On 30 August 2016, the NT EPA decided that the project requires assessment under the EA Act at the level of an Environmental Impact Statement (EIS). The NT EPA decision, which was summarised in the Terms of Reference (ToR; March 2017) and Statement of Reasons (30 August 2016), was based on the following issues:

- Potential ongoing contamination of downstream waters and groundwater associated with Acid and Metalliferous Drainage (AMD), should the site rehabilitation be inadequately designed and/or implemented.
- Disturbance of significant areas of native vegetation, which could result in significant erosion onsite if appropriate erosion and sediment control measures are not appropriately designed and/or implemented, which may result in downstream water quality impacts (*i.e.* turbidity, sedimentation) and failure to meet rehabilitation objectives (*e.g.* non-polluting, long-term stable landforms).
- Risk to humans and/or biota if radioactive materials are not appropriately managed during rehabilitation and/or disposed of appropriately (*i.e.* isolated in long-term stable landforms).
- Risks to biodiversity and threatened species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) and the *Territory Parks and Wildlife Conservation Act 2006* (NT) (TPWC Act).
- Potential social, cultural and economic impacts, including the risks of the project not realising its rehabilitation objectives.

On 22 June 2016, the Rum Jungle Rehabilitation Project (Ref: EPBC 2016/7730) was referred to the Australian Government Minister for Environment and Energy (the Australian Government Minister) for consideration under the EPBC Act. On 4 August 2016, a delegate for the Australian Government Minister decided the proposed action is a controlled action and requires assessment and approval under the EPBC Act before it can proceed. The controlling provisions protected under Part 3 of the EPBC Act are:

- Listed threatened species and communities (sections 18 & 18A).
- Protection of the environment from nuclear actions (sections 21 & 22A).

The Project is being assessed under the bilateral agreement between the Australian and Territory Governments made under section 45 of the EPBC Act.

### 1.1.1. Variation to Project

As the project advanced and additional reviews were undertaken, concept designs with lower technical risk, improved sustainability and lower cultural impacts were developed. On 23 September 2019, the Proponent submitted a written variation to the Notice of Intent to the NT EPA (pursuant to clause 14A of the *Environmental Assessment Administrative Procedures 1984*) and a variation to the original proposal to the Department of Environment and Energy (under section 156A(1) of the EPBC Act). This latter request addresses the detail required by Regulation 5.08 of the Environment Protection and Biodiversity Conservation Regulations 2000 (Cth).

On 16 October 2019 the NT EPA informed the Proponent that the significance of the altered proposal had not changed and would continue to be assessed at the EIS level; its reasons are set out in the Statement of Reasons (16 October 2019) and take into the NT EPA's Environmental Factors and Objectives framework (NT EPA, 2018). The ToR was released to the Proponent on 12 November 2019 (NT EPA, 2019b).

On 24 October 2019, the Proponent was informed *via* a delegate for the Australian Government Minister that the Australian Government had accepted the variation to the proposal in accordance with section 156B of the EPBC Act. The proposal remained a controlled action and is to be assessed under the EPBC Act prior to proceeding.

## 1.2. Proposal Overview

The Proponent, in partnership with the Commonwealth of Australia (represented by the Department of Industry, Innovation and Science (DIIS)), proposes the rehabilitation of the former Rum Jungle Mine and associated satellite mines at Mt Burton and Mt Fitch (the project). The project is located approximately 105 km south of Darwin and 6 km north of Batchelor, NT.

The project components were all formerly part of the Rum Jungle Uranium Field and consist of three land parcels as described here:

- Rum Jungle proper – Section 2968 Hundred of Goyder (vacant NT Crown land recommended for grant under the *Aboriginal Land Rights (Northern Territory) Act 1976* (Cth) (ALRA) by the Aboriginal Land Commissioner Justice Toohey on 22 May 1981);
- Mt Burton – Section 998 Hundred of Goyder (estate in fee simple held privately); and
- Mt Fitch – within NT Portion 3283 (Crown Lease Perpetual 862 held by the Northern Territory Land Corporation).

Rum Jungle Creek South (RJCS), an additional satellite site in the Rum Jungle Uranium Field, is currently held by Coomalie Community Government Council (CCGC) and is excluded from the project as no future rehabilitation works are currently planned for this site.

Additional earthen materials required to undertake the project are proposed to be sourced from two individual sites which are further components of the project:

- Low permeability materials are proposed to be sourced from pre-disturbed land owned by CCGC; and
- Granular materials are proposed to be sourced from lands including and surrounding a former sand mining area which is now located on the Finniss River Aboriginal Land Trust (FRALT).

The location of these sites are provided on the project overview at Figure 1-2. A detailed description of the project is included in Chapter 2 – Proposal Description whilst a detailed description of current site conditions is located in Chapter 6 – Existing Site Condition. For reference, Figure 1-3 shows the existing site conditions at the Rum Jungle site.

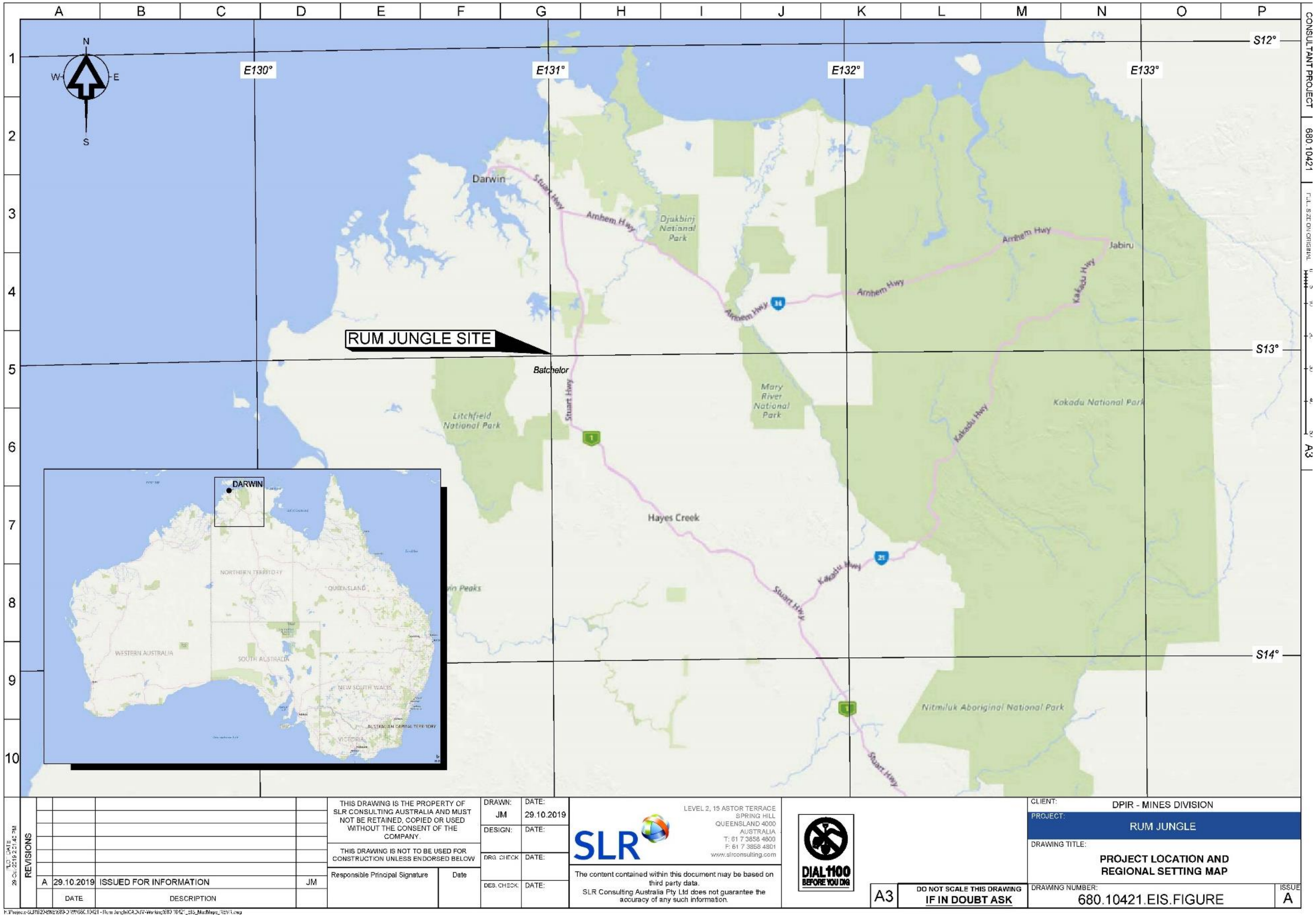


Figure 1-1: Project location and regional setting

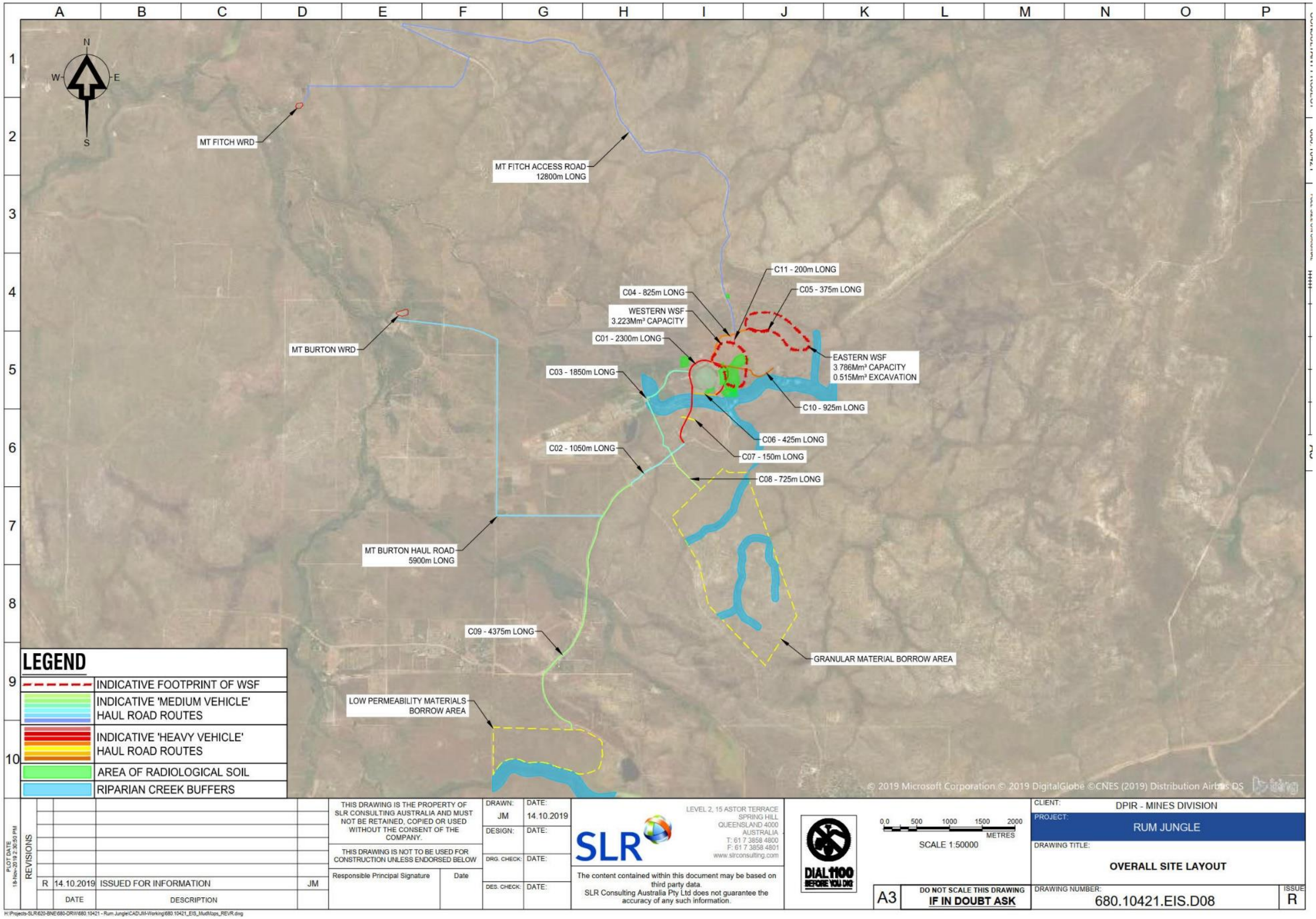


Figure 1-2: Project overview

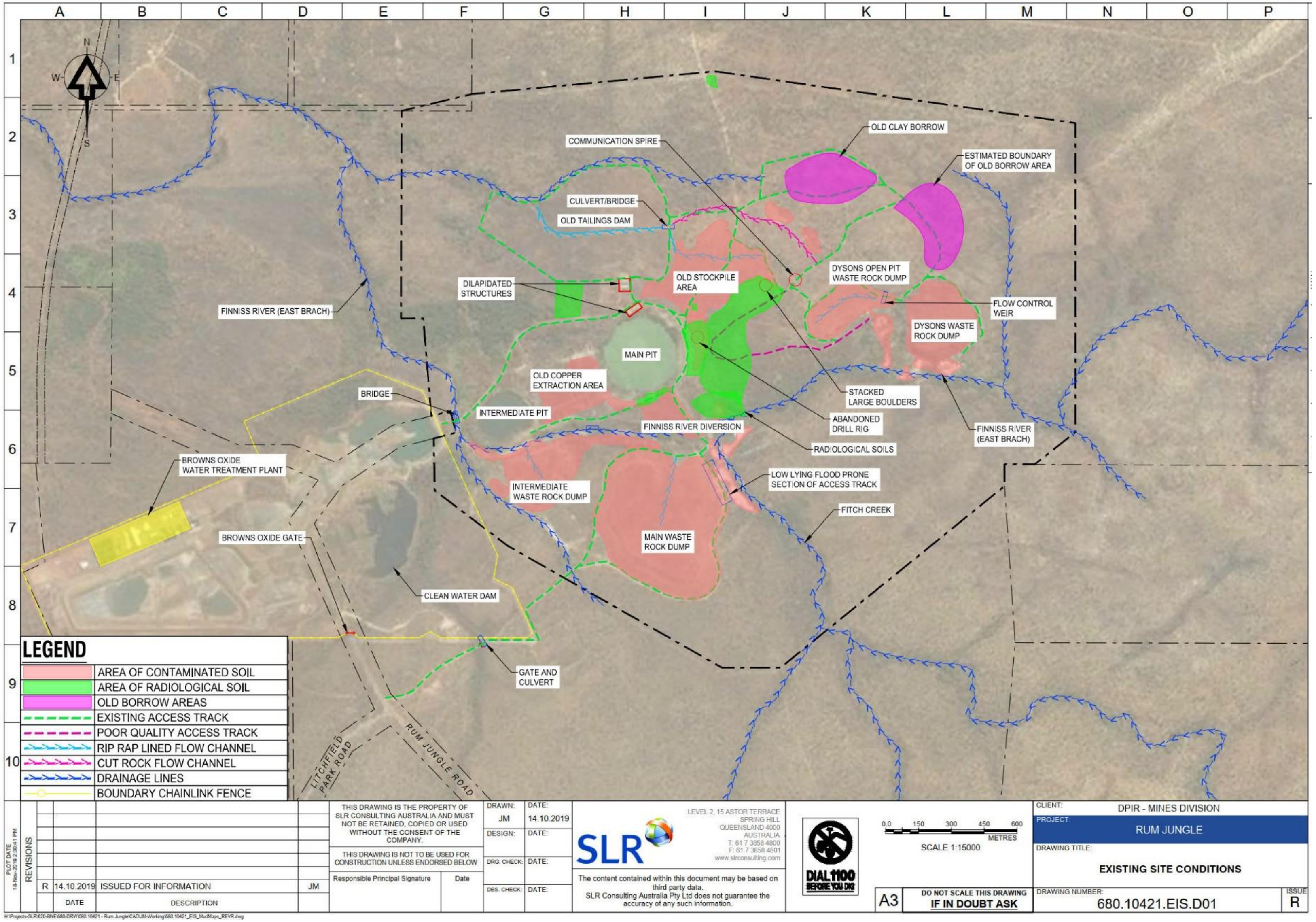


Figure 1-3: Existing site conditions at the former Rum Jungle Mine site

Key rehabilitation components for the project are summarised below:

- Waste rock most likely to produce AMD will be used to backfill Main Pit to a maximum 2 m below Dry season Standing Water Level.
- Residual waste rock from Main Waste Rock Dump (WRD), Dyson's WRD and contaminated soils (including from fluvial areas) will be consolidated into two newly constructed Waste Storage Facilities (WSF).
- Residual AMD-impacted groundwater below existing WRDs will be captured and treated prior to discharge of remediated waters to the EBFR.
- Mt Burton WRD and surrounding contaminated soils will be excavated and transported to Rum Jungle for inclusion in the new WSF.
- The new WSF will be located in the central portion of the site. The site was selected as it is previously disturbed, geologically more stable and less prone to flooding (compared to other areas on site).
- The small WRD at Mt Fitch, located directly south of the pit, and some surface disturbance evident to the west, will be relocated into the Mt Fitch Pit.
- Landform restoration and revegetation will be undertaken on disturbed areas following rehabilitation works, including newly constructed WSF, deconstructed WRD footprint areas, Old Tailings Dam area, old borrow pits, haul roads, laydowns *etc*.
- Weed and fire management programs will be implemented to assist in the successful establishment of native vegetation and improve operational safety.
- Important cultural aspects of the landscape will continue to be taken into account and where possible, actions to protect or reinstate them will be incorporated into final design.
- Access tracks will be upgraded, as required, to ensure the rehabilitation works are implemented in a safe and timely manner, this includes construction of haul roads and a culvert crossing to provide all weather access during construction.
- Based on the principles of the proposed WSF construction and capping methodologies, monitored natural attenuation of copper within the WSF is considered as the most sustainable and scientifically robust solution for seepage management.
- The EBFR flow will be diverted through Main Pit as far as possible, as requested by Custodians. The return of flow through the EBFR course holds cultural significance.
- The proposed borrow locations have been selected because of material availability and existing environmental impact caused by previous land uses including buffalo farming and sand mining. The old buffalo farm on CCGC land is heavily infested with Gamba Grass and the old sand mining location on FRALT land is already disturbed with relatively low ecological value. Overall impact on the existing environment will be minimised by utilising the materials within these areas. Haul roads will consist of a combination of public roads and constructed short haul roads.

Detail and methodologies for the key components are described in Chapter 2 – Proposal Description, Chapter 6 – Existing Environmental Condition and Chapter 7 – Rehabilitation Strategy of this EIS. The rehabilitation program for the former Rum Jungle Mine is a multi-phase process. This EIS is temporally constrained to the Stage 3 phase of this multi-phase process. The EIS will lightly touch on future stages as they pertain to the setting of objectives that may be achieved beyond this temporal scope.

Project estimated duration and scope for the purpose of the EIS are summarised below:

- <u>Construction (five years):</u> scope to consist of groundwater remediation and earthworks to isolate contaminated soils and waste rock within the WSF and Main Pit. Phase will require an initial year of mobilisation and establishment followed by 5 years of construction works.
- <u>Stabilisation and Monitoring (five years)</u>: monitoring of surface water, groundwater, erosion and rehabilitation success metrics. Monitoring and maintenance of civil structures, such as the WSF and surface water control features, will also be undertaken.

### 1.2.1. Summary of Project Objectives

The project's high-level objectives are two-fold and focus on environmental remediation and restoration of cultural values of the site as described below:

- Improve the environmental condition onsite and downstream of site within the EBFR. This includes key outcomes:
  - Surface water quality conditions within EBFR in accordance with Locally Derived Water Quality Objectives (LDWQOs).
  - Chemically and physically stable landforms.
  - Self-sustaining vegetation systems within rehabilitated landforms.
  - Physical environmental conditions supportive of the intended Land Use Plan.
- Improve onsite environmental conditions to support future land use, including cultural values:
  - Restore the flow of the EBFR to original course as far as possible.
  - Remove culturally insensitive landforms from adjacent to sacred sites and relocate ensuring a culturally safe distance from the sacred sites.
  - Return living systems including endemic species to the remaining landforms.
  - Preserve Aboriginal cultural heritage artefacts and places.
  - Isolate sources of contamination that may impact human health including radiological hazards.
  - Maximise opportunities for Traditional Owners to work onsite to aid reconnection to country.

It is envisaged that the achievement of these objectives would support potential future progress of the Finniss River Land Claim over the Rum Jungle site.

## 1.3. Mining and Rehabilitation History

The project has a long history of mining but also a rehabilitation history. Select information regarding the mining and rehabilitation are detailed below and further information is detailed in Chapter 6 - Existing Environmental Condition.

### 1.3.1. Mining

On 5 April 1948 the Commonwealth Gazette announced rewards for the discovery of uranium in Australia and its territories; the maximum reward was fixed at £25,000 (Minister for Supply and Shipping, 1948). Economically viable uranium mineralisation was discovered in the Rum Jungle area by a local prospector and farmer, John (Jack) White, in August 1949. White owned a farm on the East Branch about 5 km downstream from where he discovered a 'distinctive and unfamiliar mineral occurrence'.

During this period, it was common for prospectors to pay local Aboriginal people to bring them interesting stones (Kathy Mills, pers. comm. 2010) and some mineral discoveries in the region can be attributed to this practice. Given that Jack White had an Aboriginal partner at this time, her potential contribution to the discovery cannot be discounted.

White believed the discovery to be uraniferous, based on a Bureau of Mineral Resources pamphlet on radioactive minerals (Berkman, 1968). On 12 August 1949 White dug a trench and collected green and yellow rock samples, which he delivered to the Mines Branch in Darwin (Barrie, 1982). The Minister for the Interior announced the find on 6 September 1949 (Barrie, 1982).

White could not be granted a lease or claim because the land was freehold. Commonwealth control of material (mineral) laws also limited White's ability to obtain a lease on the land. He was paid £1,000 for his discovery in October 1950 based on a proven deposit of 25 tonnes of uranium oxide. A second payment of £7,000 was made in September 1952 after further exploration. Once a substantial body of ore was confirmed, the government paid White a third reward payment of £17,000, for a total of £25,000 (~$925,000 in 2018 dollars) for his uranium find (Barrie, 1982).

The Bureau of Mineral Resources explored the area between 1949 and 1952, confirming a viable ore deposit known as Whites. Modern terminology for the former Whites Pit and WRD has been changed at the request of Traditional Owners and is now referred to as the Main Pit and WRD. Prospective anomalies were also identified at Dyson's Deposit and Mt Fitch (Berkman, 1968). Exploration continued with two shafts sunk. On 1 November 1951 a cross-cut from one of the shafts hit ore 22 feet from the shaft, extending for a considerable distance into high-grade ore.

The Commonwealth of Australia initially held title to uranium under the *Atomic Energy (Controls of Materials) Act 1942–1952* (Cth). This Act was superseded by the *Atomic Energy Act 1953* (Cth), under which the Australian Atomic

Energy Commission (AAEC) was formed in April 1953. In 1953, the Commonwealth reserved the Hundred of Goyder, where the Rum Jungle Uranium Field is located, from occupation (Acting Administrator of the Northern Territory, 1953).

In March 1952, representatives of the United States Atomic Energy Commission (USAEC) and the United Kingdom Atomic Energy Authority (UKAEA) visited Australia and discussed the development of the Rum Jungle Uranium Field. Funds to develop the Rum Jungle Project were provided by the Combined Development Agency (CDA), with an exclusive supply contract signed between the Commonwealth and CDA (Berkman, 1968). The uranium oxide produced between 1954 and January 1963 filled the CDA supply contract. The CDA was the sole customer of the mine.

The Commonwealth entered into a Mining Agreement with the Consolidated Zinc Group on 31 December 1952 to develop and operate the Rum Jungle Project on behalf of the Commonwealth. In 1952, Consolidated Zinc formed a wholly owned subsidiary, Territory Enterprises Pty Ltd (TEP), to manage all aspects of the operation including exploration, mining and milling. The AAEC had overall control of mine operations (Berkman, 1968). On 1 January 1953, TEP took over the development and management of Rum Jungle as an agent for the Commonwealth (Davy, 1975).

The Rum Jungle Project was the first large industrial enterprise undertaken in the NT, with the total capital and operating expenditure to January 1963 being £19.6 million (~$565,700,000 in 2018 dollars), most of which was spent in the NT. Accounts from the period 1954 to January 1963 showed a total net profit of £3,380,000 (~$97,500,000 in 2018 dollars) (Davy, 1975). The national benefit from Rum Jungle was substantial. In addition to cash profits and a stockpile of uranium oxide, the operation significantly contributed to developing the NT and provided experience in mining in monsoonal conditions which provided useful lessons (Davy, 1975).

The Main Deposit was the first uranium to be mined onsite. Other ores from the Main Deposit included copper, lead, nickel and some traces of silver. After an initial proposal to mine the Main Deposit using conventional underground techniques was abandoned as being too difficult, all Rum Jungle deposits were mined *via* open pit methods.

As well as the Main Deposit, there were three other open pit mines onsite: the Main Extended Deposit (uranium); Dyson’s Deposit (uranium); and the Intermediate Deposit (copper). The Intermediate Deposit was mined by the Australian Mining and Smelting Company Ltd, also a subsidiary of the Consolidated Zinc Corporation Ltd. In addition to the copper, uranium and lead ores extracted and mined at Rum Jungle, small amounts of zinc and nickel were also mined or stockpiled for later processing (Ritchie, 1985). The sequence of historic mining activities is summarised in Table 1-1.

Table 1-1: Sequence of historic mining over the Rum Jungle Uranium Field

| Pit | Mined | Ore Produced |
|---|---|---|
| Main | 1953-1958 | Uranium/Copper/Lead* |
| Main Extended | 1957-1958 | Uranium |
| Dyson’s | 1957-1958 | Uranium |
| Rum Jungle Creek South | 1961-1963 | Uranium |
| Mt Burton | 1958-1958 | Uranium |
| Mt Fitch | 1968-1969 (exploration) | NIL |
| Intermediate | 1964-1965 | Copper |

**Lead ore was stockpiled but not processed (adapted from Verhoeven, 1988)*

Approximately 10,000 t of uranium-copper ore was also obtained from the Mt Burton deposit, 5 km west of the main Rum Jungle site. The Mt Burton Mine had relatively minor ore deposits of uranium and copper. The mineralisation, which was defined in 1954, occurred as near-surface, secondary mineralisation. Exploration drilling was carried out in 1957 and the ores were extracted in 1958 using open pit methods.

In 1966, further exploration revealed a secondary uranium and copper mineralisation on a low rise east of the Finniss River, which became known as the Mt Fitch Mine. Exploration drilling discovered another uranium deposit. Exploration activities were undertaken at Mt Fitch resulting in a small WRD and pit remaining.

The RJCS Deposit was discovered in 1959. In total, 2.43 $Mm^3$ of material was excavated from RJCS between 1961 and mid-1963, for 650,000 t of uranium ore that was stockpiled for future processing at the Rum Jungle site. The RCJS Deposit was of a higher uranium grade and quantity than both the Main and Dyson’s Deposits. An additional

114,000 t of bogum material was also stockpiled at RJCS. Eventually, the stockpiled ore was processed at Rum Jungle.

Over the course of the CDA contract, 3,530 t of uranium oxide and approximately 20,000 t of copper concentrate were produced (Davy, 1975). In total, 863,000 t of blended uranium ore (0.27– 0.43% $U_3O_8$) was treated at the Rum Jungle treatment plant. Another, 85,000 t of lead containing ore was mined and stockpiled, but not processed.

Production continued after the completion of the original supply contract in January 1963, with the uranium oxide stockpiled by the Commonwealth. The stockpile of 2,053 t of uranium oxide, which was stored at Lucas Heights near Sydney, was sold in 1993–94 and 1994–95 for electricity production in nuclear power stations in North America (Senate Uranium Mining and Milling Committee, 1997).

The uranium ore treatment plant was constructed in 1954 and operated until 1971 when the plant was closed. The plant used a standard acid leach process to extract the uranium from the crushed and milled ores.

This acid leach used sulphuric acid manufactured onsite. Until 1962, uranium was recovered from the acid leach liquor by ion exchange, followed by elution and precipitation by adding magnesia. After 1962, a solvent extraction process, using a water-immiscible organic solvent phase, was used. Uranium was stripped from the organic phase by adding alkali, followed by precipitation of the final product with caustic soda. Ore from the Main Deposit was initially treated and then as ore was stockpiled, suitable blends were made of high- and low-grade ores to maintain average feed grade of three kg/t to the treatment plant (Davy, 1975).

In addition to uranium, about 360,000 t of high-grade copper ore (> 2% Cu) was treated in the TEP plant, with a further 370,000 t of lower grade ore (0.7–2.0% Cu) heap leached. Initially, tailings from the treatment plant were deposited in a 30 ha, low flat area north-west of the plant. Later known as the Old Tailings Dam, the area was subjected to annual Wet season inundation which dispersed tailings and process liquors into the EBFR and the Finniss River.

In 1966, two separate Copper Extraction Pad heaps comprising approximately 0.3 mt (two ha) of low-grade copper sulphide and oxide ores were constructed between the Main and Intermediate Deposits. The heaps were treated with acid to extract the copper. The acid (pH2) was made from a mix of treatment plant raffinate, barren liquor and water from the Main Pit and sprayed over the top of the piles to create leaching, to produce soluble copper and sulphuric acid. The sulphide and oxide liquors were collected around the boundaries of the piles or constructed pads *via* culverts. The sulphide ore liquor was pumped back up to the top of the oxide pile where the copper was dissolved by the acid. The low-grade liquors from the oxide pile were collected in three constructed ponds: a pregnant liquor pond, an acid water pond and a barren dam pond. The low-grade liquor was pumped from the ponds to the copper launders for copper extraction *via* cementation. All overflows, including any excess barren liquor, was discharged into Copper Creek which drained into the EBFR.

Ultimately, the Copper Extraction Pad experiment was deemed commercially unviable. Approximately 3,500 t of copper was left in the heap after the mine closed. Copper sulphide ore from the heap continued to oxidise and release large concentrations of copper and other heavy metals and acid into the surrounding environment after the mine closed. The layout of site prior to the commencement of the 1980s rehabilitation works is at Figure 1-4.

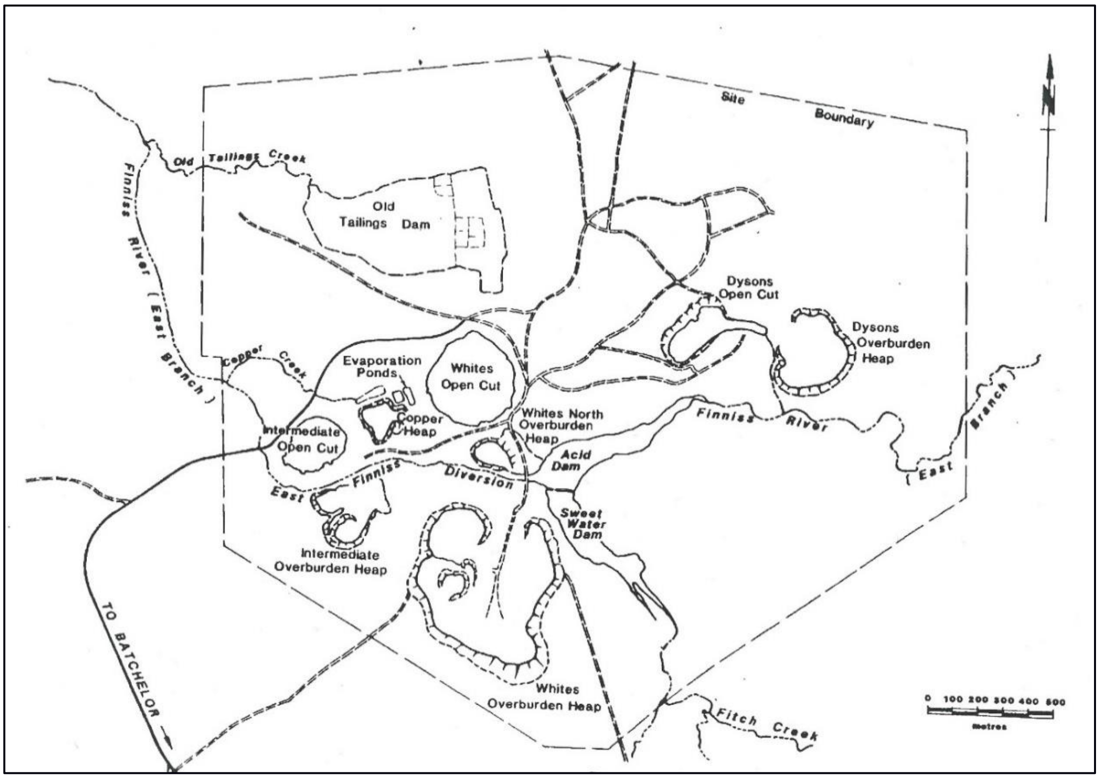


Figure 1-4: Site layout at the former Rum Jungle Mine site prior to rehabilitation (Allen and Verhoeven, 1986)

## 1.3.2. Rehabilitation

Mining and mineral processing at the site created significant environmental impacts, primarily elevated dissolved copper from AMD which polluted the EBFR. In the early 1960s, the significant environmental impacts were recognised in correspondence between the AAEC and the NT Administration (NAA: F1, 1962/1824). The Commonwealth initiated an aesthetic clean-up of the mine site in 1977. The outcome of this technical assessment and planning effort was a four year rehabilitation project funded by the Commonwealth and implemented by the NTG between 1982 and 1986.

On 4 March 1983 a $16.2 million agreement between the Commonwealth and NTG established the 1983 Agreement. The site was rehabilitated between 1983 and 1986, and the major proportion of funding was spent treating highly contaminated water in Main Pit. The Final Project Report (Allen and Verhoeven, 1986) provided a full description of the rehabilitation project, including the rationale for works and the results of preliminary monitoring. At the time, the rehabilitation was deemed to have achieved its objectives (Allen and Verhoeven, 1986).

The rehabilitated site was considered to have successfully achieved its set engineering and environmental criteria based on the results of a 12 year monitoring program undertaken between 1986 and 1998, funded jointly by the Commonwealth and NTG. The rehabilitation of the Rum Jungle site was recognised as being world-leading practice at the time, especially the installation of a multi-layer cover system. Cover system design and construction technologies were then in their infancy, so the site attracted international attention as one of the first implementations of a cover system for rehabilitation of sulfidic waste rock dumps.

According to Allen and Verhoeven (1986), the objectives of the 1980s Rum Jungle Rehabilitation Project were to:

1. Achieve a major reduction in surface water pollution, aimed at reducing the average quantities of copper (by 70%); zinc (by 70%); and manganese (by 56%) as measured at the confluence of the East Branch and the Finniss River;
2. Reduce pollution levels in the Main and Intermediate Pits;
3. Reduce public health hazards, including radiation levels at the site to at least the standards set by the *Code of Practice on Radiation Protection in the Mining and Milling of Radioactive Ores* (Commonwealth of Australia, 1980); and
4. Implement aesthetic improvements, including revegetation.

According to Allen and Verhoeven (1986), four primary rehabilitation treatments were undertaken:

- A three-layer cover system was constructed over the WRDs to reduce infiltration to less than five percent of rainfall. The WRDs were also reshaped and drainage structures installed to mitigate erosion and maintain the integrity of vegetation cover. A mix of introduced pastures and legumes were used for rapid revegetation. Grass cover was the specified revegetation condition for the WRDs.
- A water treatment plant was constructed to treat heavily contaminated water from the Main Pit. Water was withdrawn from depth, with lower density treated water returned to the surface of the pit where it formed a layer of clean water overlying the untreated water at depth. Water in the Intermediate Pit was treated *in situ* with lime to remove heavy metals and neutralise pH. Wet season flows were then re-instated through both pits so that the system would be flushed each Wet season. Based on the results from limnological modelling, it was anticipated this process would slowly cleanse the contaminated water that remained at depth in the pits by a combination of seasonal partial vertical mixing and Wet season flushing of the surface layers. Filter cake from the water treatment process was buried in Borrow Area 5, to the north of the site and capped with a three-layer cover system.
- Dyson's Pit was partially backfilled with tailings from the tailings area and Tailings Creek. The surface of the tailings was covered with a coarse geotextile and an approximately one metre thick rock blanket drainage layer. The drainage layer was overlain with low-grade copper ore, copper launders from the Copper Extraction Pad and contaminated soils from both sites. A moisture barrier, a moisture retention zone and an erosion-resistant cover were installed on top and the final surface revegetated in the same way as the WRDs.
- After the tailings were removed to Dyson's Pit, the tailings area footprint was reshaped to control drainage, limed and covered with a one-layer system (of soil) to enable revegetation with introduced pastures and native trees and shrubs.
- A sub-surface drainage system and a four-layer cover system were installed over the copper extraction area to address residual surface and sub-surface contamination. The surface was revegetated with the same methodology as the WRDs.

## 1.4. Traditional Owners

The Finniss River Land Claim No. 39 was lodged by the Northern Land Council (NLC) on behalf of claimants on 20 July 1979, under section 50(1)(a) of the ALRA. Rum Jungle formed part of the area subject to the claim. An inquiry into the claim was conducted by the Aboriginal Land Commissioner, Justice John Toohey, who presented findings in the Finniss River Land Claim No. 39 (Report No. 9) on 22 May 1981 (Commonwealth of Australia, 1981). The Aboriginal Land Commissioner recommended that the majority of land subject to the claim, including Rum Jungle, be granted to Aboriginal Land Trusts established under ALRA for the benefit of Aboriginals entitled to the use and occupation of the land. Kungarakan and Warai peoples were found to be Traditional Owners of Rum Jungle and other areas subject to claim. The Aboriginal Land Commissioner noted that it was open to the responsible Commonwealth Minister to act on all, some or none of the recommendations contained in Report No. 9.

Between 1991 and 1993, the majority of the land recommended for grant was vested in two Aboriginal Land Trusts. The Kungarakan and Warai are recognised as joint Traditional Owners of the site. No decision on the potential grant of the Rum Jungle site has been made, pending the outcome of negotiations between the Commonwealth, NTG, NLC, and Kungarakan and Warai peoples about the future of the site, including rehabilitation.

Kungarakan and Warai's objectives for rehabilitation and post-rehabilitation land use are summed up in their vision for the site. As they do not differentiate between environment and culture, their vision is largely drawn from their cultural and social principles:

> *Kungarakan and Warai desire that Rum Jungle will be returned to a natural, living environment that also provides for a return to traditional ceremony, culture and subsistence use of natural resources. In modern society, this may include development of commercial operations that are managed according to Kungarakan and Warai traditional principles.*

To Kungarakan and Warai, rehabilitation of the physical landscape will allow spiritual healing of the country.

### 1.4.1. Sacred Sites

Sacred sites on the Rum Jungle project area are detailed in the Aboriginal Areas Protection Authority (AAPA) Authority Certificate (C2019/082) and have been identified through consultation with Traditional Custodians[3]. Authority Certificates for the smaller areas around Mt Burton and Mt Fitch are yet to be obtained. Sacred sites will not be discussed in detail in this EIS in order to preserve confidentiality and respect for these sites.

### 1.4.2. Aboriginal Places and Objects

Aboriginal archaeological places and objects are afforded automatic protection under the *Heritage Act 2011* (NT), whether their location is recorded or not. The (former) NT Department of Resources commissioned an archaeological investigation of the Rum Jungle site in 2010 (Martin-Stone and Wesley, 2011) and DPIR commissioned further archaeological assessment for the Rum Jungle Rehabilitation Project Stage 2A (Martin-Stone, 2019 – see Appendix). The archaeological surveys were carried out in accordance with the NT Heritage Branch general scope of works for archaeological surveys. Previous archaeological studies have also been undertaken in the region, including a predictive model for the landscape distribution of archaeological sites in the Coomalie region (Guse, 1998), against which the survey results were assessed.

The 2010 and 2018-19 archaeological surveys identified several Aboriginal heritage objects (isolated stone artefacts) and Aboriginal heritage places within the Rum Jungle project area (Martin-Stone and Wesley, 2011; Martin-Stone, 2019). The heritage places range from small artefact scatters to more concentrated occupation sites, including a quarry and artefact production site and an extensive palimpsest.

The Aboriginal places recorded during the archaeological surveys have high cultural significance to the Traditional Owners and Custodians. When assessing their significance according to the criteria, the consultant concluded that they are significant for the following reasons:

- The variation within and between sites in terms of artefact material, type and function can tell us about the course and pattern of Aboriginal occupation of the area. They are therefore important to the course of the Territory's cultural history.
- A more detailed understanding of these places has the potential to yield information that will contribute to our understanding of the Territory's cultural history.
- The places have a strong association with the Kungarakan and Warai Traditional Owners, for cultural and spiritual reasons. More detailed understanding of these Aboriginal places has the potential to reveal stronger connections between the lifeways of the old people and their sacred sites.

Further details regarding heritage features is included within Chapter 8 - Historic and Cultural Heritage; the location of heritage features will be protected throughout this EIS to preserve confidentiality as requested by Traditional Owners.

### 1.4.3. Historical Places and Objects

Historical places and objects are only afforded legal protection in the NT if they have been nominated, assessed, and registered as Declared Heritage Places and Objects. There are currently no Declared Heritage Places and Objects within the project area.

However the drill rig, currently located near Main Pit, does meet the criteria to be considered a significant heritage object. It was independently assessed by Jared Archibald, curator of NT history at the Museum and Art Gallery of the Northern Territory. The machine is a Quarrymaster blasthole drill rig, constructed by the American engineering company, Ingersoll Rand. While the drill rig has not been nominated for consideration as a Declared Heritage Object, Archibald recommends that it should be afforded protection from destruction, either by display at a suitable place at the Rum Jungle site or by transporting it to the grounds of the Batchelor Museum for display and interpretation (Archibald, pers. comm. 2019).

## 1.5. Existing Facilities

Rum Jungle has limited facilities, including an absence of electricity and water supplies. There are select remnant structures onsite which are in disrepair. However, the Browns Oxide Mine (Northern Territory Resources), immediately adjacent to Rum Jungle (see Figure 1-3), is currently in care and maintenance. Browns Oxide could be the source of water for dust suppression, potable water, office facilities, ablutions, bulk fuel and reagent storage facilities and a functioning Water Treatment Plant (WTP). The opportunity to utilise these assets will require further investigation if the project advances.

[3] Traditional Custodians are individuals whom are identified through the AAPA process.

# 1.6. EIS Scope and Approach

This EIS has been prepared in accordance with the ToR, issued by the NT EPA, and the *General Guidance for Proponents Preparing an Environmental Impact Statement* (NT EPA, 2019a). Information on the key issues raised by the NT EPA and Department of the Environment and Energy (Cth) (DoEE), the study team, and the structure of the EIS are summarised below.

# 1.7. Key Issues Raised by the NT EPA and DoEE

Key issues as identified within the ToR and the Statements of Reasons are summarised below:

- Potential ongoing contamination of downstream waters and groundwater associated with AMD should the site rehabilitation be inadequately designed and/or implemented.
- Disturbance of significant areas of native vegetation which could result in significant erosion onsite if appropriate erosion and sediment control measures are not appropriately designed and/or implemented, which may result in downstream water quality impacts (*i.e.* turbidity, sedimentation) and failure to meet rehabilitation objectives (*e.g.* non-polluting, long-term stable landforms).
- Risk to humans and/or biota if radioactive materials are not appropriately managed during rehabilitation and/or disposed of appropriately (*i.e.* isolated in long-term stable landforms).
- Risks to biodiversity and threatened species listed under the EPBC Act and TPWC Act.
- Potential social, cultural and economic impacts, including the risks of the project not realising its rehabilitation objectives.
- Disturbance of archaeological objects/sites and/or sacred sites.
- Interaction of construction traffic with tourist traffic on public roads.
- Introduction and spread of weeds.
- Listed threatened species and communities (sections 18 & 18A of the EPBC Act).
- Protection of the environment from nuclear actions (sections 21 & 22A of the EPBC Act).

## 1.7.1. Study Team

The EIS study team is provided below in Table 1-2.

Table 1-2: Study team

| Role/Contribution | Name | Qualifications | Years Experience | Company |
|---|---|---|---|---|
| Principal Project Manager | Jackie Hartnett | Bachelor of Chemical Sciences (Hons 1A)<br>Graduate Certificate Executive Leadership | 15+ | DPIR |
| EIS Project Manager | Mitchell Thompson | Bachelor of Environmental Science | 10+ | DPIR |
| Geochemical Review | Dr David Jones | Bachelor of Science<br>PhD Chemistry | 35+ | DR Jones Environmental Excellence |
| Hydrogeology | Dr Christoph Wels | Bachelor of Science<br>PhD Hydrogeology | 25+ | RGC |
| Water and Load Balance Model Development | Patrick Bryan | Bachelor of Applied Science<br>M. Eng. Water Resources | 35+ | RGC |
| Water and Geochemistry | Dr Paul Ferguson | Bachelor of Science<br>PhD Earth Sciences | 15+ | RGC |
| Engineering Design | Danielle O'Toole | Bachelor of Engineering<br>Master of Science in Engineering | 20+ | SLR |
| Environmental Impact and Risk | Nicole Conroy | Bachelor of Applied Science | 20+ | GHD |

| | | | | |
|---|---|---|---|---|
| Environmental Impact and Risk | Henry Reynolds | Bachelor of Geology | 30+ | GHD |
| Flora, Fauna and Biodiversity and EPBC | Glen Ewers | Bachelor of Science<br>Bachelor of Law<br>Graduate Certificate Ornithology | 15+ | EcOz |
| | Kylie Welch | Bachelor of Science<br>Master Social Science | 15+ | EcOz |
| Air Noise and Vibration | Barry Cook | Bachelor of Science | 30+ | GHD |
| | Craig McVie | Bachelor of Science | 10+ | GHD |
| Historic and Cultural Heritage | Karen Martin-Stone | Bachelor of Arts | 15+ | In-Depth Archaeology |
| Socio-Economic Impact | Cassandra Buckley | Bachelor of Arts | 15+ | GHD |
| Historic and Cultural Socio-economic Impact | Lauren Harding | Master of Social Science (Social Planning)<br>Bachelor of Arts (Anthropology)<br>Certificate of Public Participation (IAP2) | 10+ | GHD |
| Geomorphology and Surface Water Quality Objectives | Dr Andy Markham | Bachelor Environmental Science<br>PhD Fluvial Geomorphology | 25+ | Hydrobiology |
| | Dr Ross Smith | Bachelor of Science<br>PhD Zoology | 30+ | Hydrobiology |
| Radiological Hazard Assessment | Bruce Ryan | Bachelor of Science<br>Master Applied Science | 25+ | EcOz |
| Visual Amenity Assessment | Dean Butcher | Bachelor Applied Science<br>Graduate Diploma Landscape Architecture | 25+ | SLR |
| Anthropology | Gareth Lewis | Bachelor Social Sciences | 20+ | GL Anthropology |
| Contaminated Sites | Paul Abbott | Bachelor of Engineering<br>Bachelor of Science | 20+ | GHD |
| Proponent's EIS Contributors | Anna Wilkins | Bachelor of Science | 2 | DPIR |
| | Virginia Leitch | Bachelor of Science (Hons)<br>Bachelor of Applied Science<br>Masters in Environmental Law<br>Graduate Certificate in Indigenous Health | 20+ | DIIS |
| | Mark Sweetman | Bachelor of Engineering | 15+ | DIIS |
| Project and EIS Development Support | Graham Farrer | Bachelor of Environmental Management<br>Graduate Certificate Science<br>Graduate Certificate Responsible Resource Development | 15+ | Project Environmental Solutions |

## 1.8. Structure of the EIS

The structure of the EIS is summarised below in Table 1-3 which includes links to the ToR.

Table 1-3: Structure of the EIS related to Terms of Reference

| **Chapter 1 – Introduction** | **Link to ToR** | **Link to General Guidance** |
|---|---|---|
| An overview of the project, its history and background, details on the Proponent, a summary of the EIS team, a summary on the regional setting in which the project will be undertaken, and summary information on the projects anticipated benefits, should it proceed. | | Part 2.1, 2.2 |
| **Chapter 2 – Project Description** | | |
| A detailed description of the project including construction sequence and layout, project duration, workforce and accommodation, transport and logistics network, handling and treatment of contaminated materials (waste rock and soil) and water treatment/water management. | Part 2.1.1, 2.1.2 | Part 2.2 |
| **Chapter 3 – Compliance and Risk** | | |
| A summary of the legislative framework, relevant guidance documents, and approvals and agreements relevant to the project. | | Part 2.3 |
| **Chapter 4 – Stakeholder Engagement and Consultation** | | |
| Additional details on how stakeholders including Traditional Owners and Custodians were engaged, consulted and communicated with throughout the project including throughout the EIS process. | | Part 2.4 |
| **Chapter 5 – Regional Setting** | | |
| A detailed description of the general project context including information on the regional context, cumulative impacts, the environmental legacy and the rehabilitation legacy. | | Part 2.5 |
| **Chapter 6 – Existing Environmental Condition** | | |
| A detailed description of compromised environmental and cultural values of the site and a description of the contamination processes. | Part 2.1.1 | Part 2.1, 2.2, 2.5 |
| **Chapter 7 – Rehabilitation Strategy** | | |
| A detailed description of the proposed actions to rehabilitate the project area including earthworks, water treatment and ecological restoration processes. | Part 2.1.2 | Part 2.1, 2.2, 2.5 |
| **Chapter 8 – Historical and Cultural Heritage** | | |
| Description of the existing conditions relative to historical and cultural heritage, assesses the potential impact of the project on historical and cultural heritage, and proposes management and mitigation measures relative to the potential impacts. | Part 2.2.6 | Part 2.6 |
| **Chapter 9 – Terrestrial Environmental Quality** | | |
| Description of the existing conditions relative to the terrestrial environment, assesses the potential impact of the project on the terrestrial environment, and proposes management and mitigation measures relative to the potential impacts. | Part 2.2.2 | Part 2.6 |
| **Chapter 10 – Inland Water Environmental Quality** | | |
| Description of the existing conditions relative to water quality, assesses the potential impact of the project on water quality, and proposes management and mitigation measures relative to the potential impacts. | Part 2.2.4 | Part 2.6 |
| **Chapter 11 – Hydrological Processes** | | |
| Description of the existing conditions relative to hydrological processes, assesses the potential impact of the project on hydrological processes, and proposes management and mitigation measures relative to the potential impacts. | Part 2.2.3 | Part 2.6 |
| **Chapter 12 – Aquatic Ecosystems** | | |
| Description of the existing conditions relative to aquatic ecosystems, assesses the potential impact of the project on aquatic ecosystems, and proposes management and mitigation measures relative to the potential impacts. | Part 2.2.5 | Part 2.6 |
| **Chapter 13 – Social and Economic Impacts** | | |
| Description of the existing conditions relative to socio-economic aspects, assesses the potential impact of the project on socio-economic aspects, and proposes management and mitigation measures relative to the potential impacts. | Part 2.2.6 | Part 2.6 |

| **Chapter 14 – Terrestrial Flora and Fauna** | | |
|---|---|---|
| Description of the existing terrestrial flora and fauna, assesses the potential impact of the project on flora and fauna, and proposes management and mitigation measures relative to the potential impacts. | Part 2.1.1, 2.2.1 | Part 2.6 |
| **Chapter 15 – Human Health and Safety** | | |
| Provides the methodology used to identify, manage, eliminate or mitigate risks to human health and safety which may result from undertaking the project. | Part 2.2.7 | Part 2.6 |
| **Chapter 16 - Radiation** | | |
| Description of the current radiological condition of site, assess the impact of the potential impact of the project on radiological conditions and proposes management and mitigation measures relative to the potential impacts. | Part 2.2.7 | Part 2.6 |
| **Chapter 17 – EPBC Act Matters** | | |
| Description of the project impacts to EPBC Act matters. Chapter includes justification for the project to have no Environmental Offsets and a description of Ecological Sustainable Development elements included into the project. | | Part 2.8, 3.6 |
| **Chapter 18 – Project Alternatives** | | |
| Provides a high level summary of key alternatives for delivery of the project including project scale alternatives and rehabilitation strategy alternatives. | Part 2.1.2 | Part 2.8, 3.6 |
| **Appendix** | | |
| Key supporting figures, documents, technical reports, and management plans that support EIS Chapters are provided. | | |

# 1.9. About the Proponent

The NTG, through DPIR, is the Proponent for the purpose of this EIS. DPIR is also responsible for regulating mining activities in the NT pursuant to the *Mining Management Act 2001* (NT). The Rum Jungle Rehabilitation Project is funded *via* a bilateral National Partnership arrangement between the NT and Commonwealth.

The implementation delivery model for Stage 3 is subject to negotiation and the development of an agreement between the Commonwealth and NT for the works summarised in this EIS. Notwithstanding any change in either the proponent or delivery model, the rehabilitation works presented in this EIS would not be subject to change.

## 1.9.1. Environmental History

The Proponent is not subject to legal proceedings related to the project and does not have a history of environmental non-compliance.

# 1.10. Proposal Background and Current Status

Rum Jungle rehabilitation planning has advanced through a feasibility evaluation process similar to the resources industry's standard scoping study/preliminary feasibility and detailed feasibility process (Table 1-4).

Table 1-4: Project background

| Stage and Year | Description |
|---|---|
| Stage 1: 2009-2013 | Traditional Owner consultation, knowledge base development, preliminary investigations and conceptual rehabilitation plan |
| Stage 2: 2013-2016 | Traditional Owner consultation, detailed engineering designs and associated cost frameworks |
| Stage 2A: 2017-2020 | Supplementary stage to improve Traditional Owner consultation, optimise engineering designs and associated cost frameworks, and undertake Environmental Impact Statement |
| Stage 3 (proposed) | Implementation of rehabilitation design through a five year Construction phase and five year intensive Post-construction Monitoring and Maintenance phase |

# 1.11. Mine Rehabilitation and Mine Closure in the Northern Territory

The importance of mine closure as a national issue was first recognised in 1992 by the Council of Australian Governments (COAG) under the *National Strategy for Ecologically Sustainable Development* (Department of Environment and Energy, 1992).

As more operational mines approach the end of their mining life and the awareness associated with the environmental, social and cultural impacts of mining, legacy mines and failed mine closure projects increases, mine rehabilitation and closure are becoming increasingly topical.

The Northern Australia mine rehabilitation and closure industry is growing rapidly with several significant mines approaching closure including Argyll Diamonds (WA), Ranger Uranium Mine and Gove Operations (both NT). Several other operational mines are likely to require progressive rehabilitation and closure planning over the coming years, and other NT mines may also become economically unviable as resources decline in quality and commodity prices shift. Woodcutters Mine (lead, zinc), immediately east of Rum Jungle, operated between 1985 and 1998, and has been implementing its Closure Plan since the early 2000s; it is currently completing maintenance and monitoring activities. In addition, it is estimated that the liability associated with legacy mines in the NT is $1 billion (DPIR, 2019).

The project, with its cultural significance and long history of rehabilitation, presents an opportunity to learn from shortcomings, develop local and regional skills in mine rehabilitation, and deliver a beneficial outcome for Traditional Owners and stakeholders alike.

# 1.12. Project Benefits and Justification

A summary of potential benefits from completing the project are included below and more detailed information is provided within respective Chapters. If the project was to not proceed, these benefits to the EBFR and surrounding environments, to Kungarakan and Warai Peoples, the local community and the mine rehabilitation/closure profession will not be realised.

## 1.12.1. Improvement in Environmental Conditions

As a result of residual contamination across the site, ongoing production of AMD and copper loads within surface water are significant and breach recommended LDWQOs. The contaminant loads ultimately flush to the EBFR and impact the aquatic ecosystem to the degree that the system is in poor health and the beneficial use of the river system for local residents and Traditional Owners is limited.

Further details regarding the project are provided in Chapter 2 - Proposal Description while further details regarding the potential environmental improvement, should the project proceed, are included in Chapter 10 - Inland Environmental Water Quality, Chapter 11 - Hydrological Processes and Chapter 12 - Aquatic Ecosystems.

## 1.12.2. Potential Resolution of the Land Claim

The Aboriginal Land Commissioner recommended that the majority of land subject to the claim, including Rum Jungle, be granted to Aboriginal Land Trusts established under ALRA for the benefit of Aboriginals entitled to the use and occupation of the land. Kungarakan and Warai Peoples were found to be Traditional Owners of Rum Jungle and other areas subject to claim. No decision on the potential grant of the Rum Jungle site has yet been made, pending the outcome of negotiations between the Commonwealth, NTG, the NLC, and Kungarakan and Warai Peoples about the future of the site, including rehabilitation. Therefore, it can be concluded that successfully undertaking the project, in partnership with Kungarakan and Warai peoples, may improve the likelihood of resolution of the remaining portion of the long-standing Finniss River Land Claim.

## 1.12.3. Kungarakan and Warai – Improved Stewardship and Increased Capacity

Both Kungarakan and Warai have expressed strong interest in developing their land management capabilities. Undertaking the project would provide funding and opportunities to improve stewardship and increase capacity which is likely to assist in cultural healing and improved economic opportunities.

Further details regarding the project are provided in Chapter 2 - Proposal Description; further details regarding Traditional Owner consultation is included in Chapter 4 - Stakeholder Engagement and Consultation; and Chapter 13 - Social and Economic Impact provides further information on the potential socio-economic benefits of the project.

### 1.12.4. Increased Capacity of Local Workforce

Undertaking the project is likely to benefit the local workforce through increased training and potential future career opportunities. Further details regarding the project are provided in Chapter 2 - Proposal Description; further details regarding stakeholder consultation is included in Chapter 4 - Stakeholder Engagement and Consultation; and Chapter 13 – Social and Economic Impact provides further information on the potential socio-economic benefits of the project.

### 1.12.5. Local and Regional Economic Impact

The project has been planned to maximise the potential local and regional economic impact. Further details regarding the project are provided in Chapter 2 - Proposal Description; further details regarding stakeholder consultation is included in Chapter 4 - Stakeholder Engagement and Consultation; and Chapter 13 – Social and Economic Impact provides further information on the potential socio-economic benefits of the project.

### 1.12.6. Rum Jungle as a Transformational Project

As summarised above, mine rehabilitation and closure are expanding fields and the Rum Jungle Rehabilitation Project offers a unique opportunity to advance the profession and provide meaningful lessons learned. Successful implementation of the project will significantly benefit the mining industry, the mine rehabilitation and closure profession, and the NTG. Further, the skills developed by professionals, Traditional Owners and local contractors will be transferrable to other mining, mine rehabilitation and closure projects. This is likely to result in increased knowledge and experience in the public arena but also increased future employment opportunities for Traditional Owners and NT companies and individuals.

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Ritchie I. (1985) The Rum Jungle Experience, a Retrospective View. *Australian Science Magazine* 4: 22-30. Darling Downs Institute Press, Australia.

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Verhoeven T.J. (1988) *Rum Jungle Rehabilitation Project*, Power and Water Authority, Darwin.

## 1.14. References included in Appendix

Martin-Stone K. (2019) *A report on the archaeological survey for Rum Jungle Rehabilitation Project – Stage 2A.* Report by In Depth Archaeology to the Department of Primary Industry and Resources, Northern Territory.

Northern Territory Environment Protection Authority (2019b) *Terms of Reference for Preparation of an Environmental Impact Statement, Rehabilitation of the former Rum Jungle Mine site*. To the Department of Primary Industry and Resources, Northern Territory.

# 2. Proposal Description

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## 2.1. Project Overview

The Proponent, in partnership with the Commonwealth, proposes the rehabilitation of the former Rum Jungle Mine and associated satellite mines at Mt Burton and Mt Fitch (the project). The project is located approximately 105 km south of Darwin and 6 km north of Batchelor, NT.

The project components were all formerly part of the Rum Jungle Uranium Field and consist of three land parcels as described here:

- Rum Jungle proper – Section 2968 Hundred of Goyder (vacant NT Crown land recommended for grant by the Aboriginal Land Commissioner Justice Toohey on 22 May 1981);
- Mt Burton – Section 998 Hundred of Goyder (estate in fee simple held privately); and
- Mt Fitch – within NT Portion 3283 (Crown Lease Perpetual 862 held by the Northern Territory Land Corporation).

Further, additional earthen materials are required to undertake the project. These materials are proposed to be sourced from two individual sites which are further components of the project:

- Low permeability materials sourced from pre-disturbed land owned by CCGC; and
- Granular materials sourced from former sand mining areas which are located on the FRALT.

The overall project layout at Figure 2-1 shows each of the project components listed above. Indicative co-ordinates (UTM zone 52S) for each area are:

- Rum Jungle Project Boundary: 716768 8564495, 718207 8564653, 719830 8564391, 719844 8562969, 718471 8561937, 718208 8561925, 717136 8562580, 716869 8563211.
- Mt Burton WRD: 713151 8564380, 713281 8564429, 713297 8564357, 713204 8564328.
- Mt Fitch Pit: 711709 8567732.
- Low permeability borrow boundary: 714618 8558035, 716034 8557981, 716219 8557642, 715948 8557304, 715377 8557521, 714616 8557531.
- Granular material boundary: 717332 8561272, 718113 8561991, 718480 8561944, 719228 8559749, 718745 8559011, 717876 8559917, 717744 8560533.

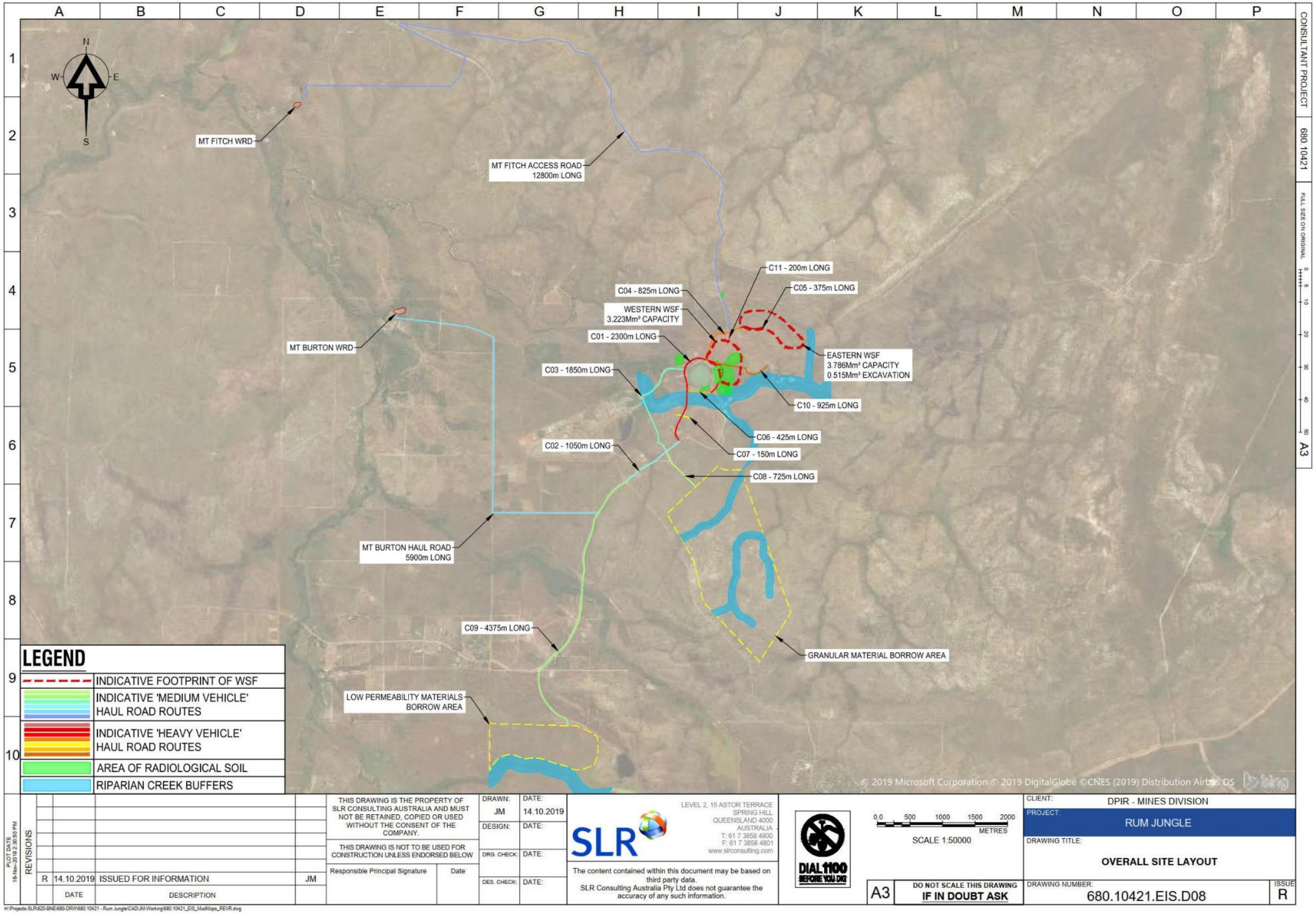


Figure 2-1: Overall site layout across project area

## 2.2. Project Implementation Strategy

The anticipated delivery of the project will require a specialist skill set, defined project management systems and appropriate governance. Details regarding the proposed project delivery and governance model are included in Figure 2-2 while the proposed workforce is detailed in Section 2.5.2.

The project delivery model will significantly influence quality, cost and overall control of project direction. While it is common practice to engage an Engineering Procurement Construction Management firm or contractor for such projects, this may result in loss of opportunity to maximise potential project benefits for the NT. Project management of large scale earthworks tasks is not the core business of the Proponent; typical project management systems are not available within DPIR. The Department of Infrastructure Planning and Logistics (DIPL) generally manages significant infrastructure projects for the NTG; however DIPL are not experienced in managing legacy mine projects.

The Proponent proposes to deliver the project as a partnership between DPIR and DIPL, should the Commonwealth and NTG reach agreement on delivery of Stage 3 works. This hybrid delivery model aims to use the strengths of both Departments to develop a delivery model which ensures all objectives are met while also maximising value for the NT. This partnership delivery model would allow the NTG to increase capacity to deliver complex legacy mines projects.

Selection of an appropriate contracting and procurement strategy will consider effectiveness, risk and cost. It is essential that the strategy is inclusive and flexible in order to realise maximum benefits at the local level, to the Kungarakan and Warai, local residents and the NT on the whole.

Procurement will be managed by the NTG with a strong weighting in favour of local and indigenous businesses. While it would be preferable to engage Kungarakan and Warai businesses to undertake rehabilitation works, the capability of these businesses to complete a large and complex project in future is unknown. As a result, joint ventures between larger contractors and Kungarakan, Warai and local business will be strongly encouraged. All procurement packages will be assessed upon their ability to engage and develop Kungarakan, Warai and local businesses for latter stages of the project and other potential regional projects.

Appropriate project governance will be an essential component of project success. Governance processes will assist in realisation of project benefits, appropriate adherence to Government policies and procedures, and to ensure that the project remains within appropriate performance metrics. The suggested governance/project management model, which is proposed to be multi-layered, and its interaction with the core project team, is detailed below in Figure 2-2.

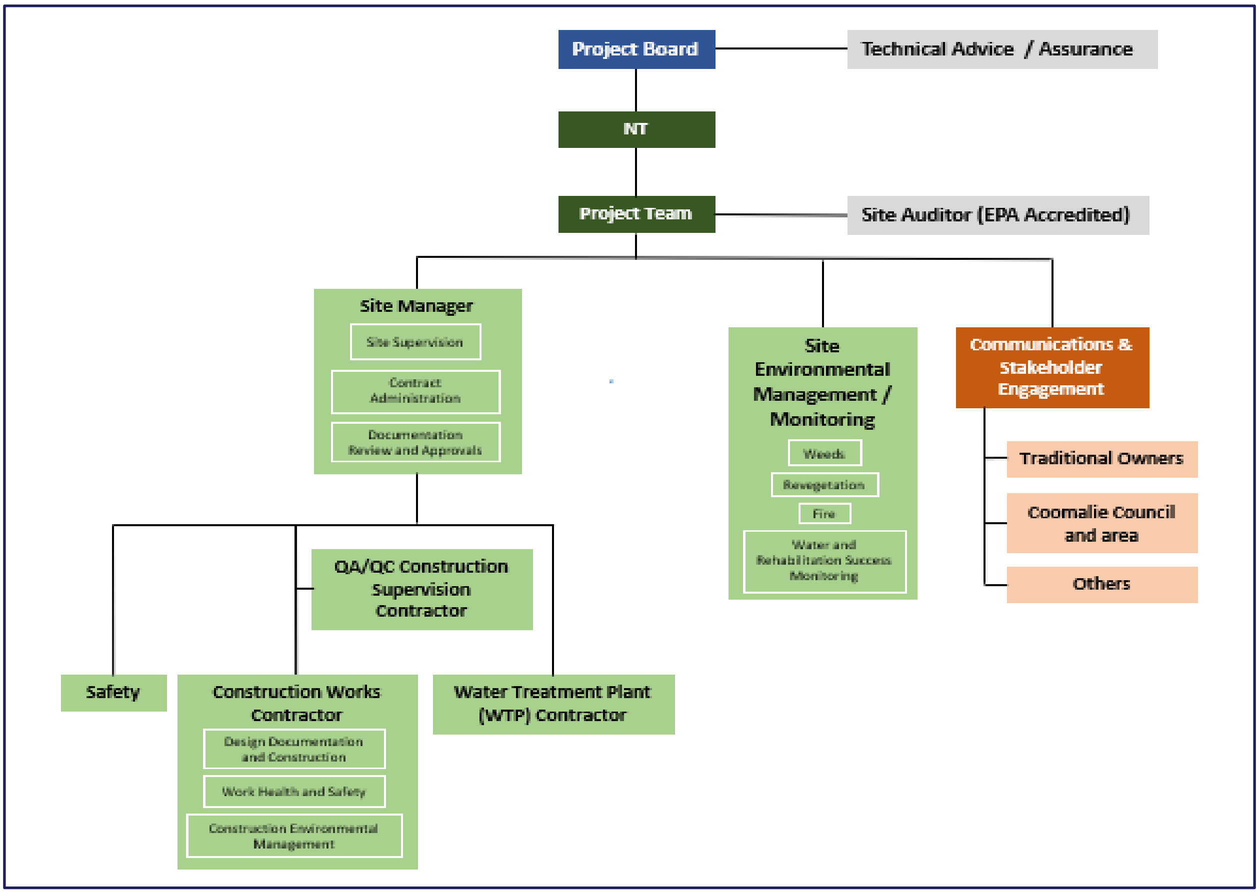


Figure 2-2: Stage 3 delivery model

## 2.3. A Contaminated Sites Approach

The primary objective of this project (see Chapter 1 - Introduction) is to restore the environmental condition onsite and downstream within the EBFR by addressing the AMD contaminant loads reporting from the Rum Jungle site to it. The current extent of contamination is described in detail in Chapter 6 – Existing Environmental Condition, Chapter 10 – Inland Water Environmental Quality and Chapter 12 – Aquatic Ecosystems. In summary, this requires:

- Addressing the current acid producing reactions with the waste rock that generate AMD. This will be done with a new storage methodology for waste rock.
- Addressing the future transportation mechanisms for AMD in the new WSF. This will be done with a new storage methodology and cover system for waste rock.
- Addressing existing sources of copper and other heavy metal contamination to the EBFR. This will be done by installing a groundwater recovery and treatment system at the existing WRDs.

The secondary objective of this project is to restore the onsite condition to safe for future land use as described in the Land Use Plan (see Figure 6-8 or Figure 7-2). In summary, this requires, amongst other actions:

- Isolating historic asbestos containing objects.
- Isolating historic radiological contaminated soils.

Underpinning both of these objectives is restoring onsite terrestrial environmental values. At present, there are several large domains onsite with poor revegetation outcomes; two areas in particular are likely the result of physical processes – excessive fire frequency and intensity, weed infestation and soil compaction. The existing vine thicket and the Old Tailings Dam area require restoration by improving physical conditions as opposed to other site landforms where chemical processes have inhibited ecological restoration.

All proposed actions are driven by removing (or reducing) the above contamination causing processes and restoring ecological function. This approach has led to the development of the scope of work for the Stage 3 Rehabilitation Project. Further details of this approach can be found at Chapter 6 – Existing Environmental Condition and Chapter 7 – Rehabilitation Strategy.

## 2.4. Stage 3 Project Stages

The scope of this EIS is temporally constrained to the Stage 3 scope of works as described in this section and generally, this refers to the Construction and Post-construction Stabilisation and Monitoring phases. The works associated with the project Stage 2B, 4 and 5 deliverables are outside of the scope of the EIS however they are interdependent in achieving the overall project objectives over the short-, medium- and long-term. The high level cross-stage project timeline is shown in Figure 2-6; the EIS scope steps are shaded a darker blue than the out-of-scope works. Each of the Construction, Stabilisation and Monitoring steps are described below.

The estimated start date for this project is difficult to determine as it must first be approved by governments and is dependent on variables outside of the project control. Therefore, the project schedule at Figure 2-3 commences at year one rather than a specific year.

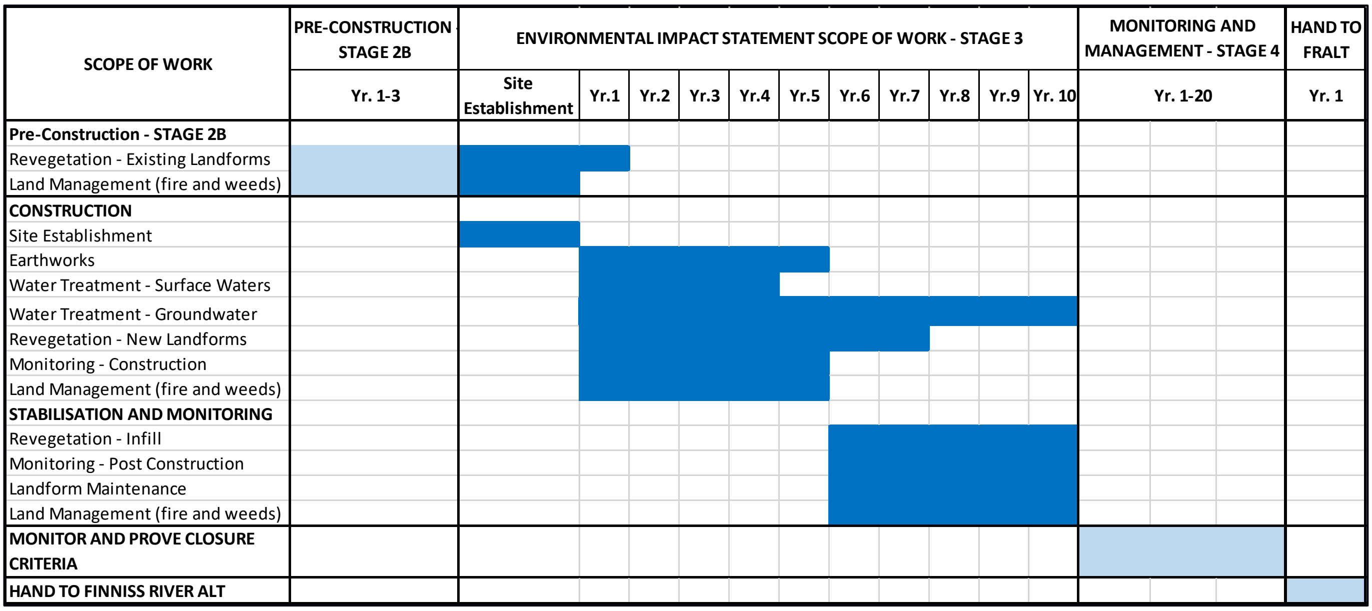


Figure 2-3: Rum Jungle Rehabilitation Project schedule

## 2.4.1. Project Establishment

During the project Establishment phase, focus will be on establishing project management systems and preliminary earthworks such as road upgrades, workshop facilities and haul road construction. It will be critical in this phase to set the standard of site operations in relation to protection of cultural and heritage values, protection of environmental values and establishment of safe work systems. Works to be carried out in Establishment include (location of works are shown on Figure 2-4):

- New haul roads to be constructed to both avoid areas of importance (cultural, historical and environmental) and also reduce haulage which will reduce greenhouse gas emissions and reduce over project costs.
- New or upgraded river crossings: several diversion channel, creek line and river crossings are required to facilitate site access during wetter months of the year. The location of river crossings has been selected to both avoid areas of importance (cultural, historical and environmental) and reduce haul lengths to reduce greenhouse gas emissions and project costs. Generally temporary culvert crossings will be used so that they can be removed during demobilisation.
- Office compound facilities: the preference is to utilise existing office, ablution and laboratory facilities that are in place at the Browns Oxide Mine adjacent to the Rum Jungle site. If an agreement cannot be reached with the Mine, it is proposed to locate office compound facilities adjacent to the workshop area.
- Other infrastructure: locations for other infrastructure, such as workshops and go-lines and the water treatment area, have been selected primarily to avoid areas of importance (cultural, historical and environmental) but also to be practically located near to work areas.

## 2.4.2. Earthworks – New WSF Foundation Preparation

This project step is necessary to prepare for relocation of waste rock and will be undertaken progressively over the first five years of the Construction phase. This step also presents the opportunity to maximise the re-use of excavated foundation materials for haul road and laydown area construction, and within the new WSF cover system. Optimisation of the materials removed from the WSF footprint will have a compounding improvement in the final WSF geometry as it improves the volume of stored waste rock below grade whilst reducing the demand for cover materials and final facility height above grade. The approximate footprints of the WSF is detailed on

Figure 2-5.

Foundation preparation will also include development of internal drainage structures for the purpose of monitored natural attenuation of any seepage generated by the Facility.

### 2.4.3. Earthworks – Relocation of Waste Rock and Contaminated Soils (including WSF Construction)

The relocation of waste rock and contaminated soils will occur throughout the first five years of the Construction phase. The purpose of relocating the waste rock and contaminated soil is to store these materials safely in a manner that isolates contaminants from the environment and future land users, and stabilises the acid production reactions within the acid forming waste rock. Contaminated soils are to be stored within the WSF. Waste rock is to be stored in one of three locations:

- Main Pit backfill
- Eastern WSF
- Western WSF.

The materials nominated for permanent storage within the Main Pit backfill are those with the highest acid forming potential:

- Intermediate WRD
- Dyson's (backfilled) Pit – materials formerly from the Copper Extraction Pad
- Main WRD – the remaining volume that can be stored within Main Pit.

All remaining contaminated soils and waste rock will be stored in the Eastern and Western WSFs (which form the entire WSF). The location of the WSF is noted in

Figure 2-5.

Detail on the construction methodology for both the Main Pit backfill and WSF can be found at Chapter 7 – Rehabilitation Strategy. Transportation of contaminated soils and waste rock will be carried out using internal haul road networks except in the case where Mt Burton waste rock is hauled to site for safe storage within the WSF. The areas of contaminated soil and waste rock is provided on Figure 2-6 and the waste material movement by year is provided in Figure 2-8.

### 2.4.4. Earthworks – Cover Systems

The development of cover systems for the WSF and the residual WRD footprints will take place progressively over the life of the Construction phase. The purpose of the cover system for the residual WRD footprints is to develop a viable surface for vegetation establishment, therefore it must include:

- sufficient depth and drainage properties for root development (estimated as 2 m) for local woodland species;
- sufficient quality and quantity topsoil to inoculate the area with symbiotic soil microbes, provide nutrients and seed bank; and
- sufficient erosion control structures to stabilise the newly formed surface.

The purpose of the WSF cover system is to exclude, as far as practicable, the diffusion of oxygen into the waste rock mass, the net percolation of rainfall and to provide a sufficient matrix for development of shrubs and grasses. Therefore the WSF cover system must include:

- a low permeability barrier;
- a store and release layer to improve available soil moisture;
- topsoil layers for inoculation of microbes, nutrients and seed bank;
- rock mulching to improve erosion protection; and
- surface water drainage systems to safely convey plateau area catchment down to natural surface.

Further details can be found in Chapter 7 – Rehabilitation Strategy. Cover system installation will occur throughout the first five years of the Construction phase. Cover materials are to be sourced from within the WSF footprint and from two potential borrow areas located on the adjacent FRALT and a freehold parcel held by CCGC. These potential borrow areas are shown in Figure 2-1. It is critical to note that at the time of producing this EIS, no formal agreements have been developed between the Proponent and the landowners though preliminary discussions have taken place.

These potential borrow locations have been selected for inclusion within the EIS as:

- suitable material types are present;
- they have been assessed for low ecological and cultural values;
- they are within a reasonable haul distance;
- no sacred sites, objects or places are present; and
- they provide a development opportunity for the two most critical project stakeholders – Traditional Owners and CCGC.

The cover placement methodology is directly related to the WSF construction methodology; further detail can be found in Chapter 7 – Rehabilitation Strategy.

It is estimated that approximately 3.2 $Mm^3$ of cover materials will be required for the project. These materials will be transported to site using both public and private roads at approximately 58-65 truck movements *per* day for the five years. The proposed public haul route is provided on Figure 2-1 and Figure 2-4.

### 2.4.5. Water Treatment – Surface Waters

The Main Pit backfilling and remediation methodology is described in Chapter 7 – Rehabilitation Strategy and requires progressive surface water abstraction from the Main and Intermediate Pits over the pit backfilling process. Existing stored water within the Main Pit must be removed to make way for the backfilled waste rock volume and stored water within the Intermediate Pit is to be kept at a nominated elevation (approximately 8 m below current Dry season levels) to allow sufficient storage capacity for high rainfall events over the pits' catchment. The purpose of this is to ensure a low chance of uncontrolled overflow of pit waters from the site during construction. The target operational water elevation for Intermediate Pit has been set to allow sufficient storage volume whist not drawing down so far as to accelerate expression of copper impacted groundwater to the Intermediate Pit or to drawdown surrounding groundwater which would impact an adjacent Groundwater-Dependant Ecosystem (GDE).

Therefore, the purpose of the surface water treatment activities is to ensure that there is a low risk of uncontrolled overflow of pit waters to the EBFR during the Construction phase. Additionally, the purpose of the treatment activities are to ensure that all waters leaving site to the EBFR are treated to the appropriate Construction Water Quality Trigger Values. This is described in detail in Chapter 7 – Rehabilitation Strategy and Chapter 10 – Inland Water Environmental Quality.

It is proposed to pump and treat surface waters over the period of pit backfilling only; this includes a requirement to conduct pump and treat activities during the Dry season as described in detail in Chapter 10 – Inland Water Environmental Quality and Chapter 11 – Hydrological Processes.

### 2.4.6. Water Treatment – Groundwater

The purpose of the groundwater treatment scope is to recover and treat historically AMD-impacted groundwater plumes and shallow seepage within the existing Main and Intermediate WRDs as they are directly contributing the majority of the copper loading to the EBFR at present. Relocating and adequately storing this waste rock will isolate this source of copper loading in future, however residual copper contamination plumes will persist for an unknown length of time if untreated.

Recovery bores will be installed near the Main and Intermediate WRDs, and a sump will be installed to collect seepage along the eastern toe of the Main WRD (along the access road). This system is referred to as a Seepage Interception System (SIS). The SIS will address the majority of copper contamination that currently reports to the EBFR. Recovery bores will also be installed in the Copper Extraction Pad area and former ore stockpile area to remediate groundwater in these areas. Groundwater in these areas do not appear to report to the EBFR so the bores are intended to improve groundwater quality in these locations and reduce the extent of residual contaminant plumes. It is planned to install the SIS in Year 1 of the Construction phase and continue operation of the system for 10 years. Further detail is available in Chapter 10 – Inland Water Environmental Quality.

### 2.4.7. Construction – Cultural Centre

Both Kungarakan and Warai have expressed a strong interest in the construction of a cultural centre. The cultural centre will communicate the history of Kungarakan and Warai peoples, and the importance of Rum Jungle to them: their displacement during mining, details of mining itself and the Rehabilitation Project. In addition, if artefacts require relocation during construction, they will be managed as *per* the Cultural Heritage Management Plan (CHMP) and potentially displayed within the cultural centre as *per* Traditional Owner requirements. Further details of potential artefact relocation is detailed within Chapter 8 – Historic and Cultural Heritage. While the proposed location of the cultural centre is yet to be decided indicative locations are noted on Figure 2-7.

The cultural centre is planned for construction in the Construction phase, and the final location and layout for this facility will be determined in consultation with Traditional Owners.

### 2.4.8. Construction – Decommissioning and Demobilisation

The purpose of this stage is to remove all facilities from the site after the construction works are complete. The majority of the decommissioning will take place in Year 6 of the construction schedule; however the groundwater SIS infrastructure and WTP will stay in place until decommissioned in the final year of the Construction phase. This scope of work includes:

- Removal of all haul roads and river crossings that are not required by the future land owners.
- Removal of all project related infrastructure that is not required by the future land owners.
- Removal of all project related equipment.

This stage could be expedited if an agreement can be made to lease facilities at Browns Oxide Mine.

### 2.4.9. Construction – Land Management, Revegetation and Monitoring

The purpose of the Construction Phase Monitoring Plan is to ensure that the rehabilitation operations are not exacerbating impacts to the already impacted EBFR. This will also include monitoring impacts to community and neighbouring properties. Monitoring programs are recommended in each Chapter of this EIS. Monitoring will take place over the entire Stage 3.

The purpose of the Construction phase land management activities are to ensure that appropriate measures are taken to reduce the risk of uncontrolled weed spread and uncontrolled bushfire. Both of these elements have potential to negatively impact on revegetation success on new landforms. Additionally, uncontrolled bushfire presents a significant safety risk to operational personnel. These are discussed in detail within this EIS. Land management activities will take place over the entire Stage 3.

The purpose of the Construction phase revegetation program is tri-fold – to establish self-sustaining vegetation systems on new landforms, to physically stabilise new landforms and to develop vegetation systems that will form the foundation for ecosystem restoration. Revegetation activities will take place across the entire Stage 3 and will also be incorporated into the Stage 2B scope of work.

These activities may form the foundation for a future Traditional Owner ranger training program which would benefit all people and lands of the FRALT. Ideally, for successful site restoration the skills and resources for site specific monitoring, land management and revegetation are developed during the Stage 2B scope of works. Further details of the revegetation strategy can be found at Chapter 7 – Rehabilitation Strategy and Chapter 14 – Terrestrial Flora and Fauna.

### 2.4.10. Stabilisation and Monitoring

Following completion of the earthworks (including Main Pit backfilling), a five year Stabilisation and Monitoring phase (Years 6-10 of the project) is planned. The purpose of this phase is to provide a sufficient period of time for intensive site monitoring while the new landforms are settling. Over this period of time, vegetation systems should commence taking over the role of surface stabilisation whilst the engineering erosion controls are also performing their role. During this period it is expected that landform settlement may cause minor erosion. The following practices are expected to take place:

- Active feral animal control.
- Minor erosion repairs.
- Infill planting of all revegetation areas - this may include succession planting.
- Active fire and weed management including first burns in revegetation areas once vegetation is at a sufficient growth stage.

The monitoring regime for this period will target the identification of issues arising that may require repair or mitigation works and will then phase into monitoring trends of rehabilitation metrics. This may extend into Stage 4 as defined in the schedule above. Proposed rehabilitation success metrics that pertain to the objectives of the Stage 3 works are presented in Chapter 7 – Rehabilitation Strategy.

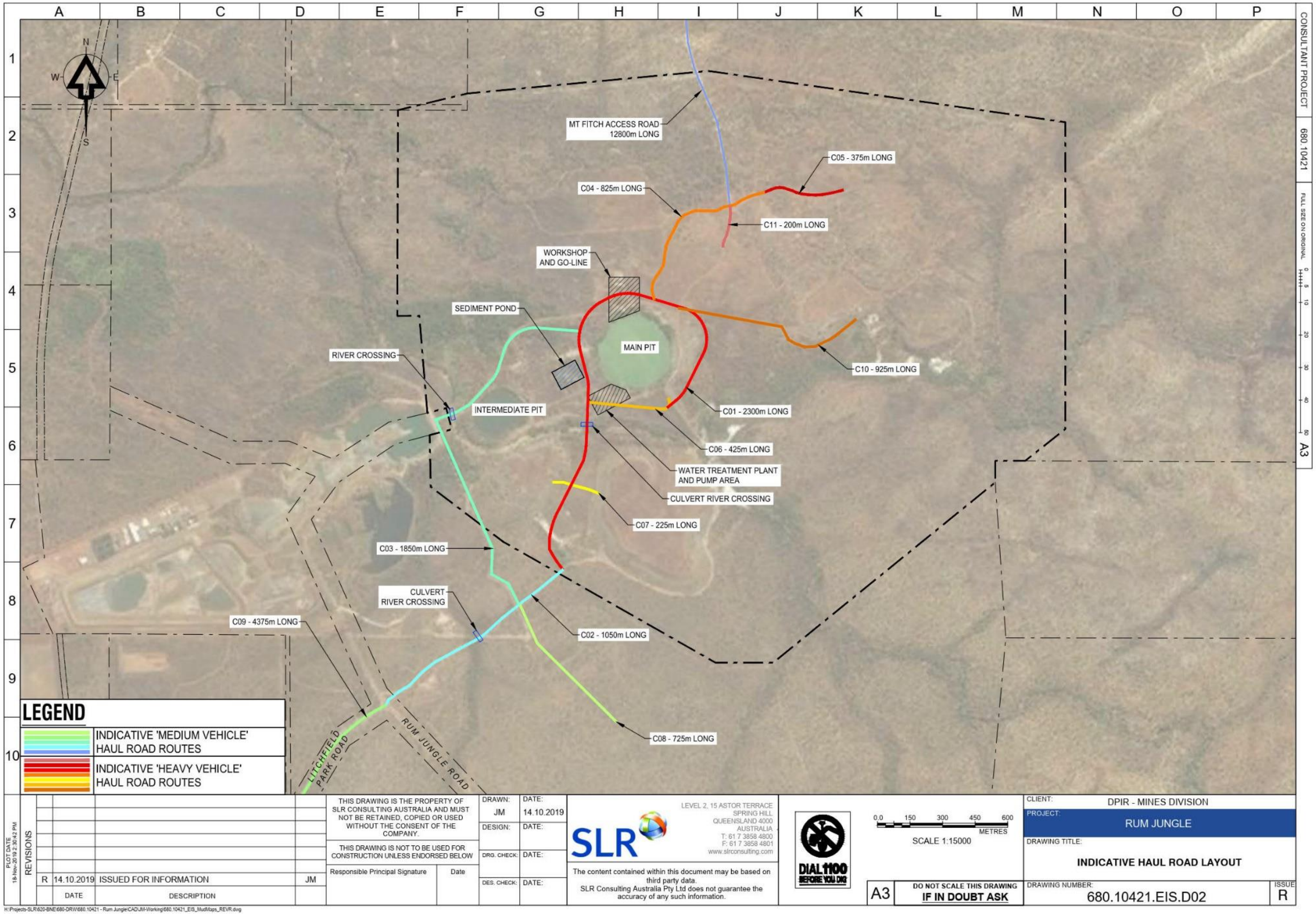


Figure 2-4: Indicative haul road layout

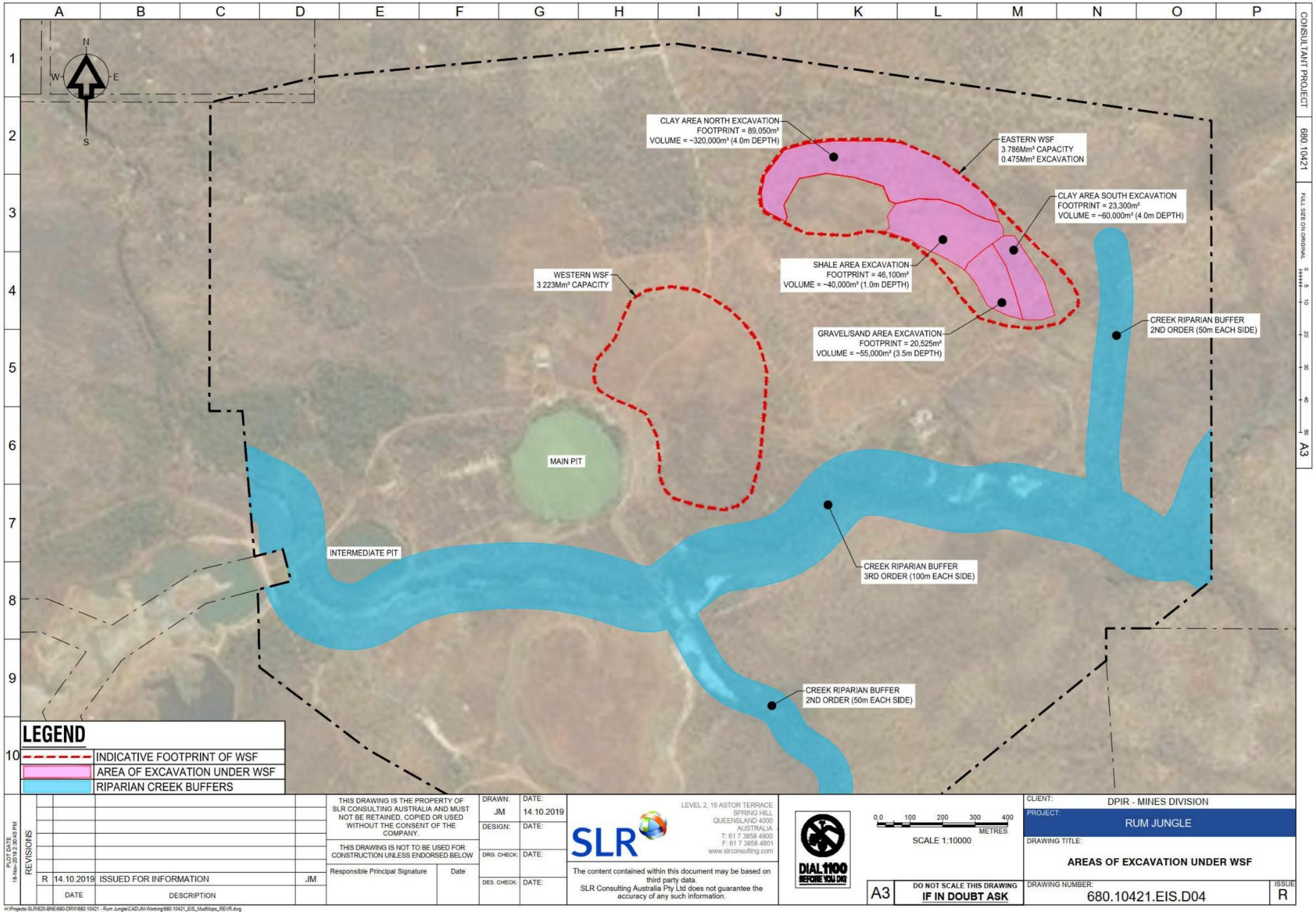


Figure 2-5: Areas of excavation under WSF

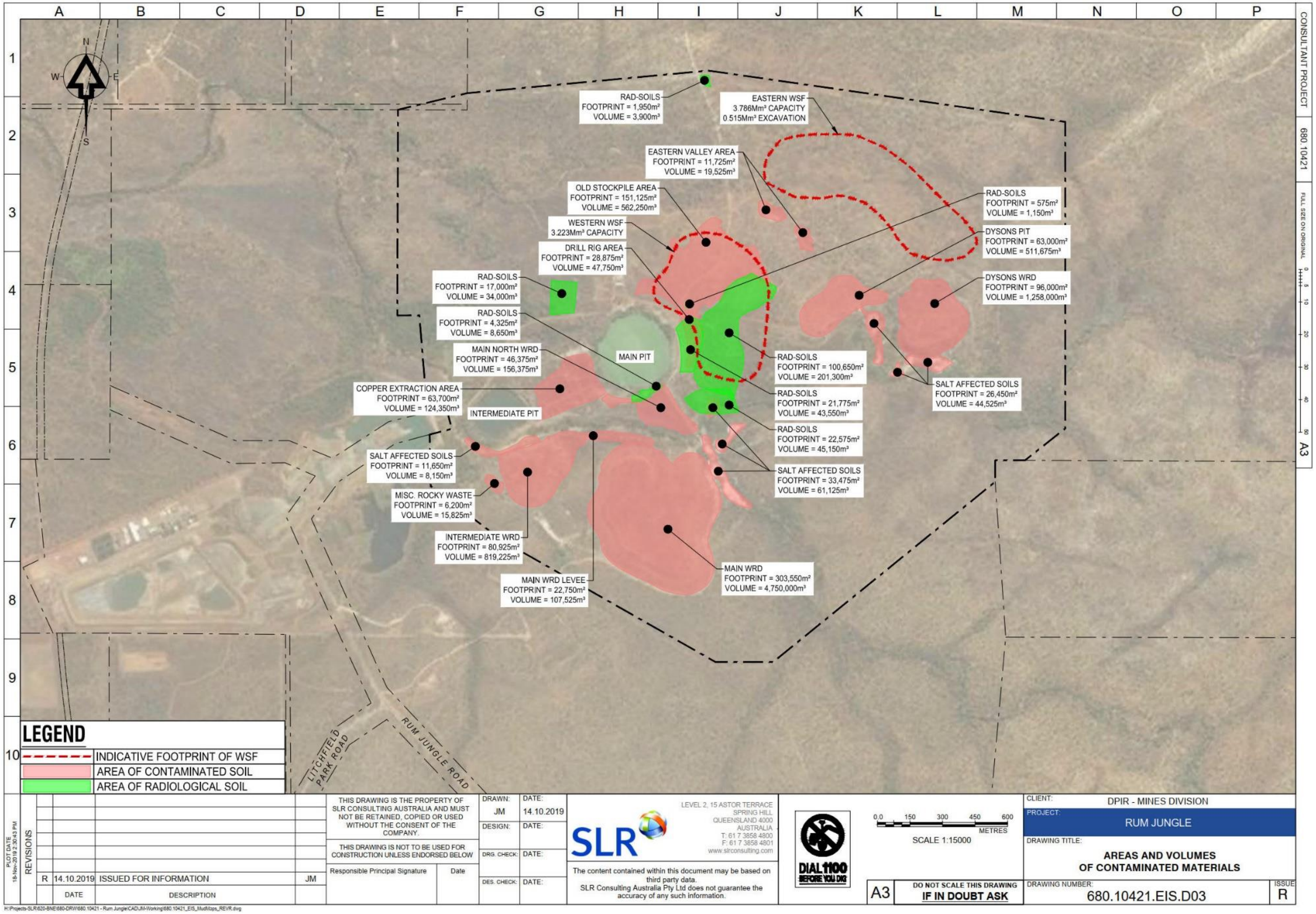


Figure 2-6: Areas and volumes of contaminated soils for excavation

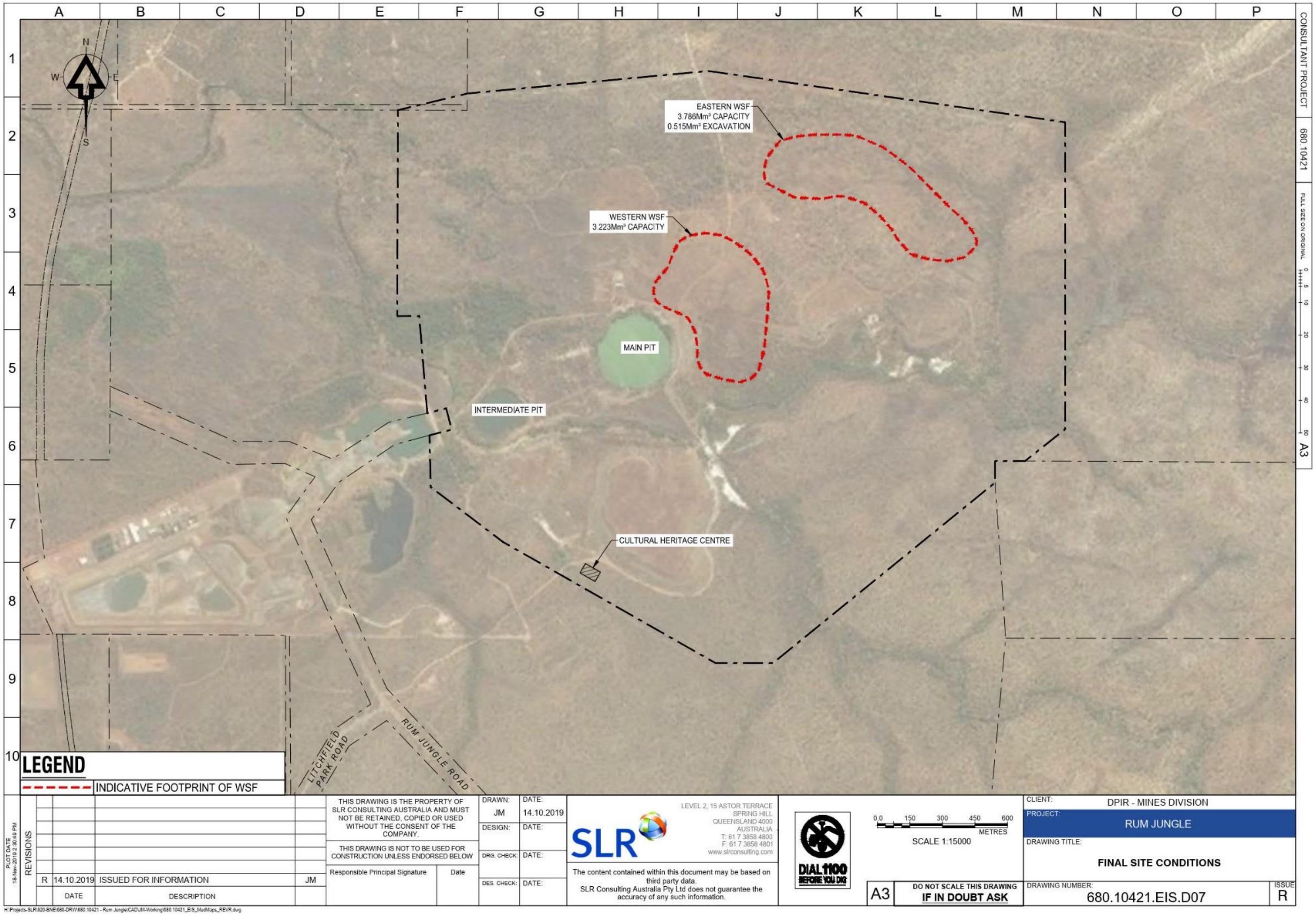


Figure 2-7: Final site conditions

# 2.5. Stage 3 Schedule Inputs and Outputs

## 2.5.1. Material Movement

The majority of the material movements will involve the transport of waste rock and contaminated soils within site and the importing of clean cover materials from off site. Material movement is scheduled for both Wet and Dry seasons with adequate controls planned to manage risk presented by Wet season operations. These are described throughout this EIS. The estimated production rates are summarised in Table 2-1.

Table 2-1: Estimated material movement rates

| Material | Activity | Dry Season Rate (1 May to 1 December) | Wet Season Rate (1 December to 1 May) |
|---|---|---|---|
| **Main Pit Backfilling** | | | |
| Waste rock from Intermediate WRD, Dyson's (backfilled) Pit and Main WRD | Load to stockpile, dose lime on conveyor, conveyor to barge, place in Main Pit over water. | 2,580 $m^3$/day | 1,380 $m^3$/day |
| **New Waste Storage Facility Construction** | | | |
| Waste rock and contaminated soil from across the Rum Jungle site | Load, haul, place, lime dose, mix, nominally compact into new WSF. | 5,000 $m^3$/day | 3,000 $m^3$/day |
| Radiological soils from Rum Jungle site | Load, haul, place, nominally compact, and cover into new WSF. | 5,000 $m^3$/day | |
| Waste rock from Mt Burton | Load, haul, place, nominally compact, and cover into new WSF.<br>Haul is along a significant length of private haul roads. | 2,500 $m^3$/day | 1,500 $m^3$/day |
| Low permeability materials (including clay) from the borrow area near RJCS | Load, haul, place, compact and test for:<br>• External containment walls<br>• Capping layer.<br>Haul is along public access. | 600 $m^3$/day | 500 $m^3$/day |
| Granular materials (including sands and gravels) from the borrow area on FRALT | Load, haul, place and compact for road construction and assistance with capping layer in Main Pit.<br>Haul is along private access. | 600 $m^3$/day | 500 $m^3$/day |

The Construction phase annual waste material movement and sequence is summarised in Figure 2-8. This schedule sees the Main Pit backfilling operation taking place at the same time as the WSF construction process. Future detailed scheduling may decouple these processes which would see an extension of the project timeframe and a reduction in work intensity.

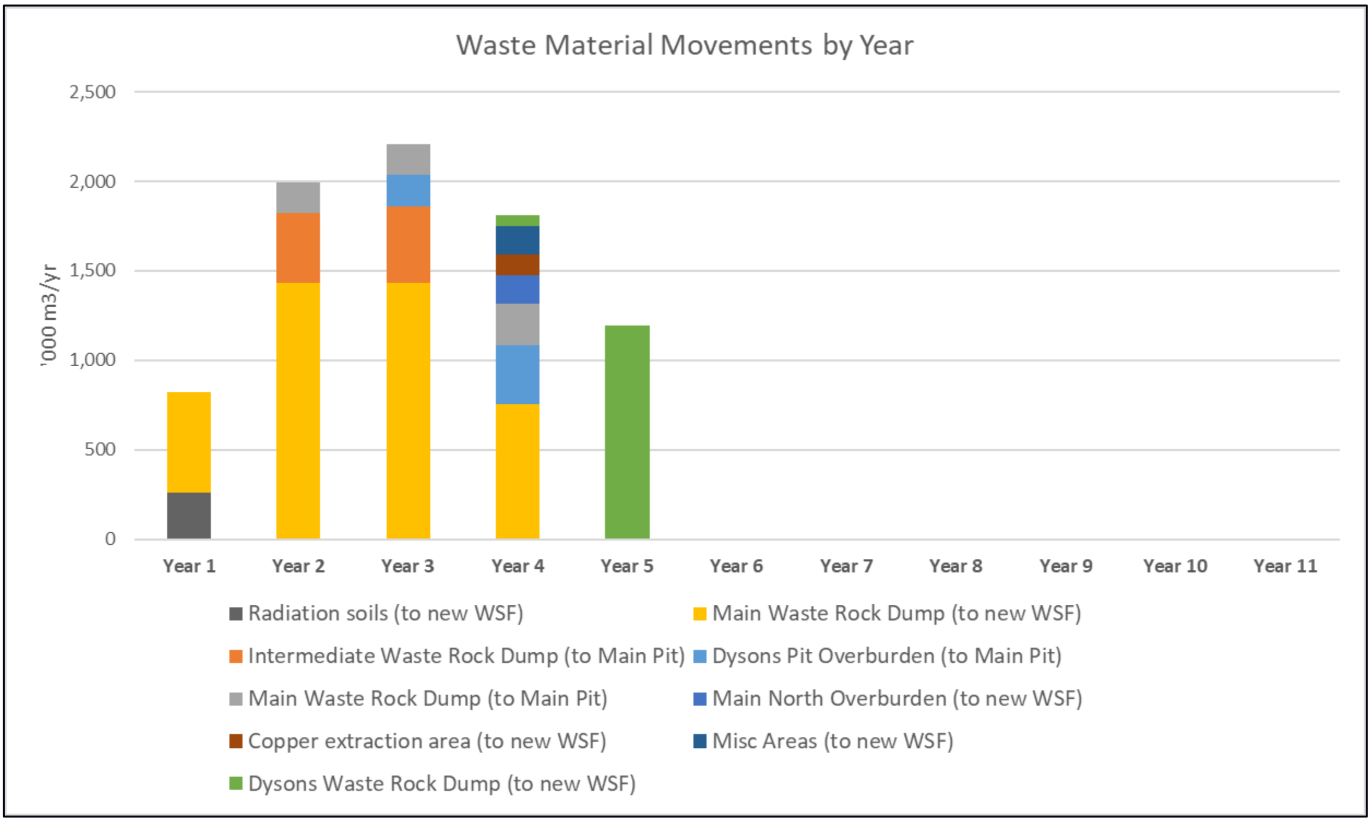


Figure 2-8: Waste material movement schedule

All waste rock relocated through this project will require lime amendment at rates dependant on the material characterisation. The lime amendment methodology has been developed with an appropriate level of conservatism as the long term AMD production risk is the highest environmental risk posed by the project. Two sets of lime dose values have been determined by Robertson GeoConsultants and Jones (2019) for the two scenarios where PAF (Potentially Acid Forming) can be segregated efficiently or not. These estimated volumes are shown here in Figure 2-9.

Lime is anticipated to be sourced from Mataranka and transported by road. Diesel to support this operation is anticipated to be sourced from Darwin and northern ports and will be transported by road.

**Table 5-9.**

**Estimates of Lime Requirement for Waste Rock assuming segregation of PAF types**

| Type | Current Location | Lime requirement, kg $CaCO_3$/t | Tonnage Re-Located, Mt | $CaCO_3$ Required, t |
|---|---|---|---|---|
| PAF-I | Intermediate WRD | 24 | 1.2 | 28,800 |
| PAF-II | Intermediate WRD | 16 | 0.3 | 4,800 |
| PAF-I | Dyson's Pit backfill | 24 | 0.6 | 14,400 |
| PAF-II | Dyson's Pit backfill | 16 | 0.2 | 3,200 |
| PAF-III | Dyson's Pit backfill | 8 | 0.09 | 700 |
| PAF-I | Main WRD | 24 | 1.3 | 31,200 |
| PAF-II | Main WRD | 16 | 3.1 | 49,600 |
| PAF-III | Main WRD | 8 | 2.2 | 17,600 |
| NAF | Main WRD | 0 | 2.2 | 0 |
| PAF-II | Dyson's WRD | 16 | 0.3 | 4,800 |
| PAF-III | Dyson's WRD | 8 | 0.9 | 7,200 |
| NAF | Dyson's WRD | 0 | 1.0 | 0 |
| Soils* | Around the site | 0 | 1.0 | 0 |
| | **TOTAL:** | **-** | **14.4** | **162,300** |

Note 1: If the PAF types cannot be segregated as indicated in this Table then a larger amount of neutralant will be needed to maintain the required conservatism (see Table 5.10).

Note 2: Main WRD includes the small Main North WRD.

Note 3: NAF waste rock would not be amended with lime (assuming it could be segregated from PAF waste rock).

**Table 5-10.**

**Estimates of Lime Requirement for Waste Rock without segregation of PAF types**

| Type | Current Location | Lime requirement, kg $CaCO_3$/t | Tonnage Re-Located, Mt | $CaCO_3$ Required, t |
|---|---|---|---|---|
| PAF-I | Intermediate WRD | 24 | 1.5 | 36,000 |
| PAF-I | Dyson's Pit backfill | 24 | 0.9 | 21,600 |
| PAF-II | Main WRD | 16 | 8.8 | 140,800 |
| PAF-III | Dyson's WRD | 8 | 2.2 | 17,600 |
| Soils* | Around the site | 0 | 1.0 | 0 |
| | **TOTAL:** | **-** | **14.4** | **216,000** |

Figure 2-9: Estimated Lime Mass for Waste Rock Amendment (Robertson GeoConsultants and Jones, 2019)

## 2.5.2. Workforce

The Workforce Plan has been designed to maximise Kungarakan and Warai, and local employment opportunities and the positive economic impact on Batchelor and the region. Select decisions to achieve the above are summarised below:

- All work will be conducted on day shift.
- Shifts will be 12 hours *per* day, seven days *per* week.
- A single crew will be utilised (with the exception of possible maintenance work and security).

- With regards to sourcing the workforce, the following will be prioritised:
  - Kungarakan and Warai;
  - Local residents;
  - NT residents;
  - National residents; and finally
  - International residents.

The project will adopt a no fly in fly out (FIFO) workforce policy to increase the positive impact to the Batchelor region. Specialist consultants may travel from interstate or overseas as required. With a preference to local or NT residents, transport to and from site will be provided by bus services from Batchelor. If portions of the workforce are not located within Batchelor, these members of the workforce will be drive in drive out (DIDO) but accommodated in Batchelor during their shift. Estimated employment numbers and roles are detailed graphically in Figure 2-10:10. It should be noted that the employment numbers and roles does not consider training or capacity building.

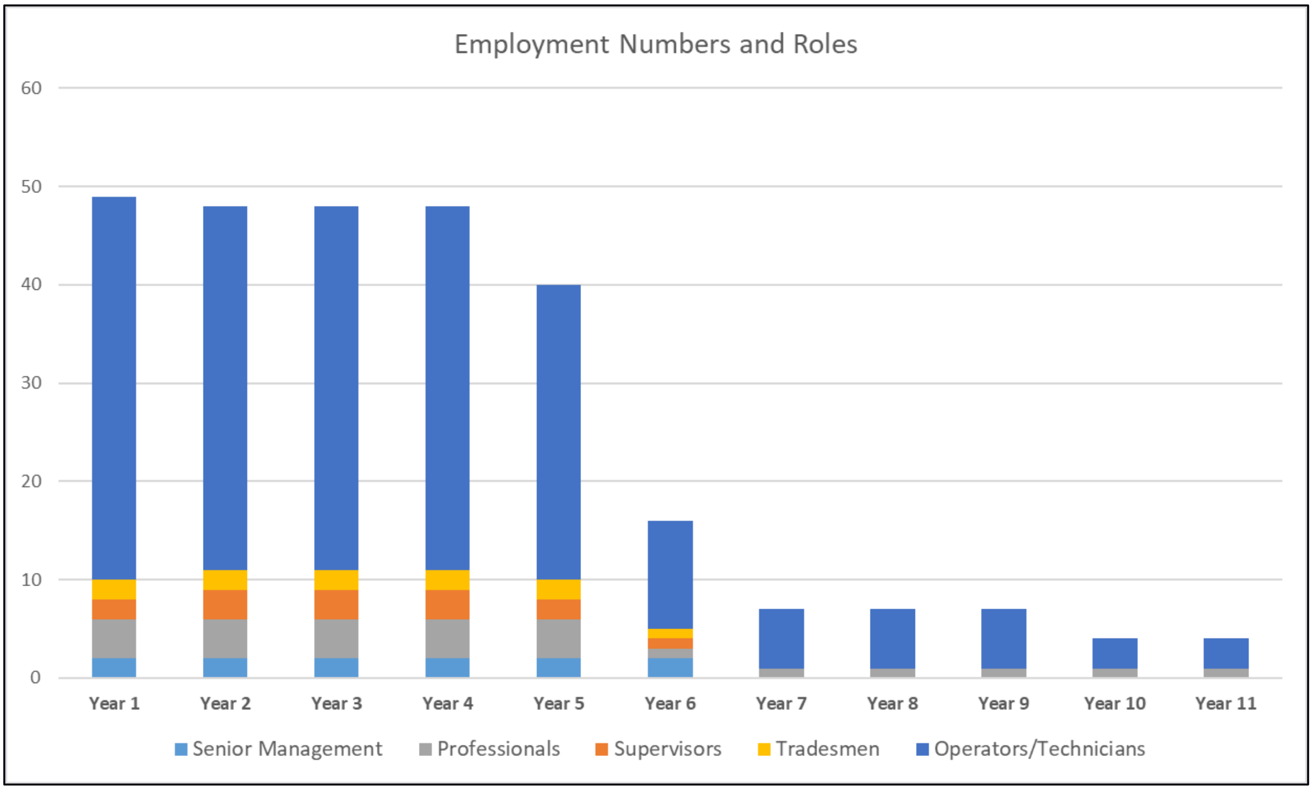


Figure 2-10: Employment numbers and roles

## 2.5.3. Accommodation

It is anticipated that all workers would be accommodated in Batchelor during their shift. As *per* the project Accommodation Strategy, the non-residential workforce will be accommodated in existing rental housing and accommodation facilities in Batchelor. There are currently four houses available in Batchelor for rent and approximately 35 houses available for sale. Social and Economic Impact Assessment (SEIA) consultation indicated that several houses have been listed for sale for several years and private property owners would likely be willing to rent their property to project construction workers. SEIA consultation also indicated that there are private properties leased as holiday rentals in the region and these property owners may also be willing to rent their properties to project workers. This will benefit property owners who earn rental income.

As part of the project's Accommodation Strategy, procurement of local accommodation will need to be undertaken in line with the NTG's procurement process. Due to its location at the entry to Litchfield National Park, there is a range of tourism accommodation options close to and within Batchelor. As confirmed during SEIA consultation, the tourism industry is highly valued by the local community for providing employment and economic opportunities. SEIA consultation indicated that most tourism accommodation has limited availability during the Dry season and that tourism accommodation providers would not necessarily want to make their accommodation available for project workers. See

Chapter 13 - Social and Economic Impacts and the *SEIA Rum Jungle Rehabilitation Project Report* (GHD, 2019e – see Appendix) for more detail on the SEIA.

A non-residential workforce will lead to a small increase in demand for accommodation in Batchelor and surrounds. As accommodation facilities are generally at capacity during the tourist season, demand from a non-residential project workforce could impact on the regional tourism industry. However, a number of other accommodation options for the project workforce are available, which will avoid impacts on tourism as well as generate benefits for local housing and accommodation providers. These options are listed below and will form part of the project Accommodation Strategy:

- Long term leases with available rental or sale housing properties;
- Batchelor Institute of Indigenous Tertiary Education (BIITE) campus accommodation; or
- Increase capacity of existing temporary accommodation facilities.

## 2.5.4. Transport and Logistics Network

Wherever possible, the project has planned to use internal haul roads for transportation of construction materials. Where public roads are proposed, the haul distance has been optimised as far as practical. Overall, there are several material types and access routes on public roads that are planned. At this stage, the project has commenced preliminary discussions with the NT Department of Infrastructure, Planning and Logistics (DIPL) on the approvals processes for utilising public roads. It is of the highest priority that public safety is maintained therefore the project will be following the established DIPL processes for Traffic Impact Assessment and the appropriate permits and approvals will be sought.

In summary the materials that require movement over public roads include:

- Bulk diesel for use in construction fleet and onsite power generation (3-5 trucks *per* week).
- Bulk lime for use in waste rock neutralisation in the WSF and Main Pit backfilling (1 truck *per* day).
- Specialised consumables such as geofabrics, quarry rock and other materials.
- Borrow material from the low permeability material borrow area adjacent to RJCS (27 trucks *per* day).

Detailed project scheduling will include activities to minimise impact on public roads including seasonal movement of borrow materials to reduce truck volumes over the tourist Dry season. The detailed Traffic Impact Assessment and approvals process will guide final plans for the project's transport and logistics network.

## 2.5.5. Construction Fleet

The estimated equipment numbers and types are provided graphically in Figure 2-11 and detailed at Table 2-2.

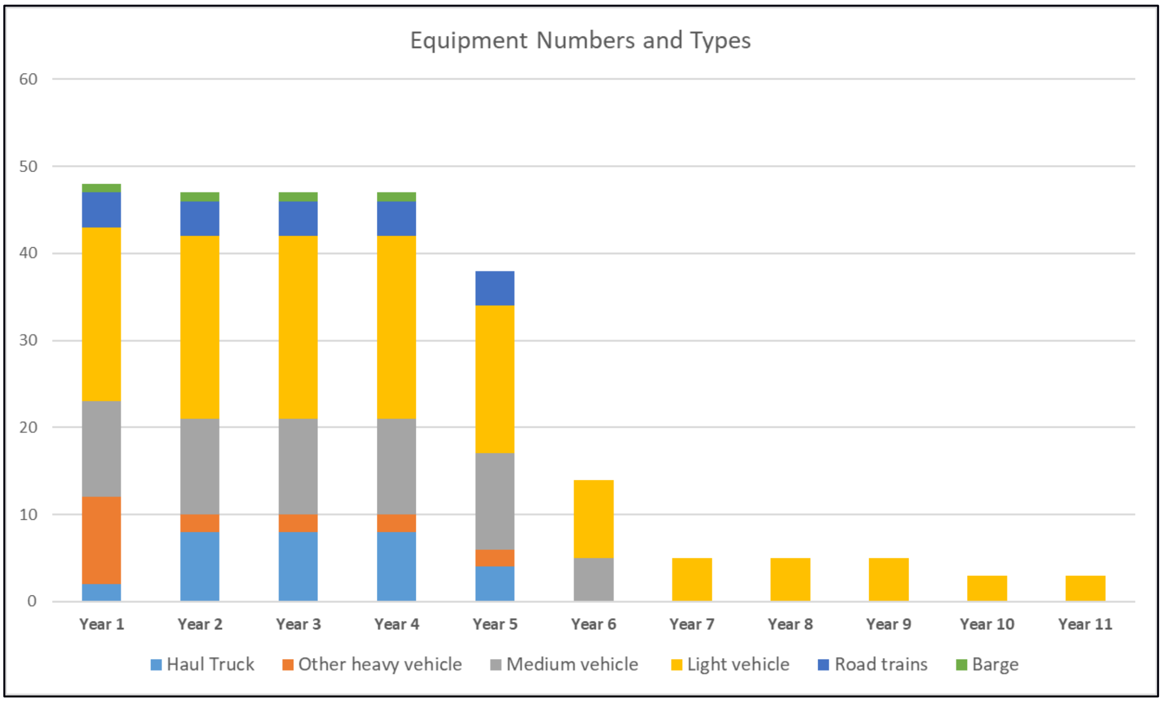


Figure 2-11: Estimated equipment and types

Table 2-2: Equipment list

| Construction Activity | Equipment Required |
|---|---|
| Construct haul roads and other establishment tasks | 1 x excavator/shovel<br>3 x Cat 777<br>1 x grader<br>2 x 835 compactors<br>2 x smooth drum rollers |
| Excavate contaminated waste rock or soil and haul to new WSF (within project boundaries) | 1 x excavator/shovel<br>4 x Cat 777 |
| Mix waste rock and lime, and conveyor to barge for placement in Main Pit | Hopper<br>Conveyor<br>Barge |
| Excavate contaminated waste rock or soil and haul to new WSF (from Mt Burton) and Mt Fitch pit backfill | 1 x excavator/shovel<br>4 x Cat 777 |
| Place, lime and nominally compact soil and waste rock in new WSF | 1 x D9 dozer with tyne<br>1 x spreader/stabiliser<br>2 x 825 compactors<br>1 x smooth drum roller |
| Haul from low permeability material borrow area to the project | 1 x excavator<br>2 x B-double road trains |
| Haul from granular material borrow area to the project | 1 x excavator<br>2 x B-double road trains |
| Ancillary earthworks support equipment | 2 x water trucks<br>1 x grader<br>1 x fuel truck<br>1 x maintenance truck<br>1 x material movement truck (ITP)<br>6 x light vehicles |
| Water treatment activities | 1 x barge |

## 2.5.6. Estimated Areas of Disturbance

Wherever possible, the project has attempted to avoid disturbing areas of quality vegetation, preferring to use areas which have previously been historically disturbed. The total areas to be disturbed and an estimate of the percentage of previously disturbed land is summarised at Table 2-3. It is important to note that the areas documented for the two potential borrow pits do not represent the likely actual area of disturbance that will occur. For example, the granular material borrow footprint is 2,529,600m$^2$, however it is estimated that only around half of this will be required for the final borrow. This is due to the fact that no land use agreements have been reached with both potential borrow landholders; therefore the total maximum areas have been included in Table 2-3. The agreement making process may identify that landowners may wish to reduce the total land disturbance or to avoid disturbance in certain areas. This is yet to be explored with landowners.

Table 2-3: Project land disturbance

| Project Component | Total Mapped Area ($m^2$)* | Planned Disturbance Area ($m^2$) | Estimated Previously Disturbed Land (%) | New Clearing ($m^2$) |
|---|---|---|---|---|
| WSF East and West | 705,650 | - | 90% | 71,000 |
| Contaminated soils | 993,300 | - | 100% | - |
| Haul roads | 9,435 m length | - | 95% | - |
| Other infrastructure | 50,000 | - | 100% | - |
| Low Permeability Material Borrow | 918,300 | 400,821 | 95% | 20,000 |
| Granular Material Borrow | 2,529,600 | 400,821 | 40% | 20,000 |

## 2.5.7. Water Management

Water management for the project consists of several key water treatment tasks in order to restore environmental values. These are noted in Sections 2.4.5 and 2.4.6 above. Surface water quality onsite will also be impacted by the open waste rock faces and will require a dedicated Erosion and Sediment Control Plan (ESCP). This is discussed further in Chapter 10 – Inland Water Environmental Quality, Chapter 11 – Hydrological Processes and the *Water Management Plan* (DPIR, 2019 – see Appendix).

In addition to this, several construction activities are required in order to maintain safe site access and reduce risk of flooding the Main Pit backfill work area. These construction activities are:

- Upgrade existing bridge between the Browns Oxide and Rum Jungle sites.
- Upgrade culvert crossings into the Rum Jungle site.
- Block all EBFR flows from entering Main Pit during backfilling operations and ensure full passage through the current diversion channel.
- Divert the EBFR back through the Main Pit Lake after completion of backfilling operations. This will satisfy the Custodian and Traditional Owner requirement to return the EBFR to its original course through site.

Project construction water will be required in order to achieve dust suppression objectives and WSF lime mixing and placement tasks. It is expected that the WTP will deliver water quality suitable for these tasks. Additional construction water will be sourced from the Browns Oxide site in the unlikely event that it is required.

As the majority of site workers will be accommodated within the Batchelor community, there will not be an onsite camp. However, site offices will be required to accommodate approximately 11 professional staff and crib facilities for approximately 34 staff. In the event that no lease agreement can be reached with Browns Oxide Mine, these onsite offices will require potable water and wash rooms, resulting in grey water and sewerage, which will require management.

It is anticipated that potable water requirements will be approximately 6,000 L/day (40 workers, 150 L each for radiation hygiene and drinking) which will be either produced onsite or under agreement with Browns Oxide Mine. Grey water and sewerage will be stored in onsite septic tanks and periodically collected and managed by local or Darwin liquid waste management contractors.

Construction water demand is estimated at 1 ML/day for dust suppression and 0.25 ML/day for WSF construction over the dry season. This will reduce over the wetter months.

# 2.6. Ancillary Infrastructure

## 2.6.1. Electricity Supply

Electricity demand will largely be the result of WTP and SIS operations, offices, ablutions, bulk fuel farm, laboratory and the servicing workshop. In the event that an agreement can be reached with Browns Oxide Mine for use of its ablutions, offices, laboratory, water treatment and/or bulk fuel farm facilities, these facilities will not need to be constructed and powered onsite. The SIS and workshop will be powered onsite regardless of any agreement with Browns Oxide Mine.

High level investigation has found that it may be possible to power, by solar components, infrastructure such as the groundwater abstraction bores, offices and other low density power uses. The cultural centre will be solar powered in order to reduce operational costs. The high demand power uses are the WTP and workshop which are currently planned to be powered by diesel generators. The reason for this is to simplify the decommissioning processes. If any project changes occur, such as a need to upscale the WTP once studies are at completion or if no agreement can be reached with Browns Oxide Mine for water treatment, grid connected power may be required to run this plant.

## 2.6.2. Waste Management

Waste management is legislated by the *Waste Management and Pollution Control Act 1998* (NT) and the Waste Management and Pollution Control (Administration) Regulations 1998 (NT). It is anticipated that waste streams produced by the project will consist of:

- Solid waste from the WTP.
- Domestic waste from the offices.
- Construction and demolition waste.
- Sewage.
- Waste hydrocarbons and hydrocarbon contaminated wastes from the workshop.

In order to reduce the volume of domestic waste which is destined for landfill, waste will be segregated to maximise recycling rates. Further, partnerships will be formed with NT waste contractors and CCGC to ensure prompt service and maximum recycling rates. An operational Waste Management Plan (WMP) and system will be developed in line with the waste management hierarchy (**Error! Reference source not found.**) which summarises the objectives of the *Waste Management Strategy for the Northern Territory 2015-2022* (NT EPA, 2015). The emergency management of waste material will be addressed within the Emergency Management Plans (EMPs).

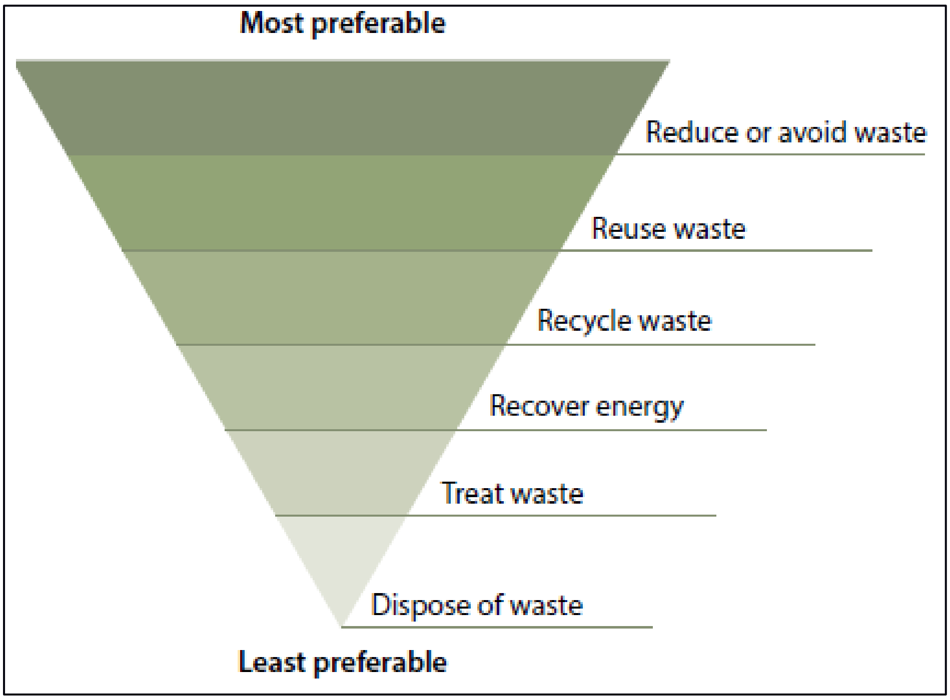


Figure 2-12: Waste hierarchy (adapted from NT EPA, 2015)

Two main forms of water related waste will be produced during Stage 3 of the project - solids from the WTP and grey water and sewage. Groundwater will be abstracted from the impacted sites and treated *via* conventional 'off the shelf' technology. Clean water will be returned to Intermediate Pit. Solids removed from waste water treatment will be disposed of in the WSF in accordance with the WMP. Grey water and sewerage will be stored in onsite septic tanks specifically designed for the purpose which will be periodically collected and managed by local liquid waste management contractors. Further details on water management is provided within Chapter 10 – Inland Water Environmental Quality, Chapter 11 – Hydrological Processes and in the WMP. EMPs will be developed to further address waste management issues that are not already covered in the WMP.

## 2.6.3. Communications

Communication systems for site are critical to safe and efficient operations. Systems will need to be established for site operations, from site to NTG offices and across the key supporting service providers. The required communication channels consist of:

- Onsite radio communication: is an essential component of the project, both in terms of site safety and efficiency. While radio communication onsite is generally effective, there are certain 'black spots' across site. An upgrade of the existing system is required.
- Local mobile phone communication: is present but often unreliable. It is proposed to engage a contract communication specialist to assist with installing a semi-permanent booster tower to cover site and surrounds.
- NT mobile phone communication: should #2 above be resolved, communication between site, Darwin and other national hubs should be reliable. This will be an essential as key stakeholders (including the Project Partner, the Australian Government) are located interstate.
- Onsite internet connection: is critical in maintaining effective administrative functions. Browns Oxide Mine site currently access internet *via* mobile broadband.

## 2.6.4. Maintenance Workshop, Chemical and Hydrocarbon Storage/Transport

The workshop and go-line area (see Figure 2-4) will be the location for fleet maintenance activities. Additionally, the bulk lime required for waste rock neutralisation and water treatment will be stored undercover in this area. The bulk fuel farm, in the event no agreement is reached with Browns Oxide Mine) will be located adjacent to the workshop. There may be other water treatment chemicals required for storage onsite such as flocculants, acids and alkalis.

These facilities will be built, materials stored and handled in accordance with manufacturer's specifications, and the relevant legislation and Australian Standards including:

- AS 1692-2006 - Steel tanks for flammable and combustible liquids
- AS 1940:2017 - The storage and handling of flammable and combustible liquids
- AS 1940:2017/AMDT 1:2019 -The storage and handling of flammable and combustible liquids
- AS/NZS 3833-2007 - The storage and handling of mixed classes of dangerous goods, in packages and intermediate bulk containers.

Generally, environmental controls for the workshop will include concrete flooring, undercover work areas, contained and treated drainage systems, and bunding of hydrocarbon storage areas. Waste oil will be stored within the bunded workshop area and will be periodically removed from site by a licenced waste management contractor.

The movement and handling of chemicals outside of workplaces is carried out under the *Australian Code for the Transport of Dangerous Goods by Road and Rail* (Commonwealth of Australia, 2018) adopted by the *Transport of Dangerous Goods by Road and Rail (National Uniform Legislation) Act 2010* (NT) and the Transport of Dangerous Goods by Road and Rail (National Uniform Legislation) Regulations 2011 (NT). Only contractors which are licenced to transport the required chemicals and fuels, and are in compliance with the aforementioned Act and Regulations, will be engaged by the Proponent. Site procedures and equipment for spill identification, response, clean-up and reporting will be outlined within EMPs and appropriate training will be provided to personnel and recorded.

Water treatment plant chemicals will be determined on final detailed design of the WTP and volumes are unlikely to be significant compared to the stored lime and diesel requirements. The relevant Australian Standards will be applied for the storage and use of WTP chemicals.

<u>Greenhouse Gas Emissions</u>

Diesel will be required to fuel the construction fleet and generators, which will provide all electricity needs for the site. Based on the construction schedule and construction fleet as detailed above, it is anticipated that diesel use will be approximately 2.5 ML *per* year over the first five years of the Construction phase when earthworks and Main Pit backfilling is undertaken. This is estimated to produce a carbon footprint of approximately 6,898 t $CO_2$-e *per* year during these peak operations years. Fuel will be stored in a properly maintained (and code-compliant) storage area and is expected to be used entirely leaving no waste.

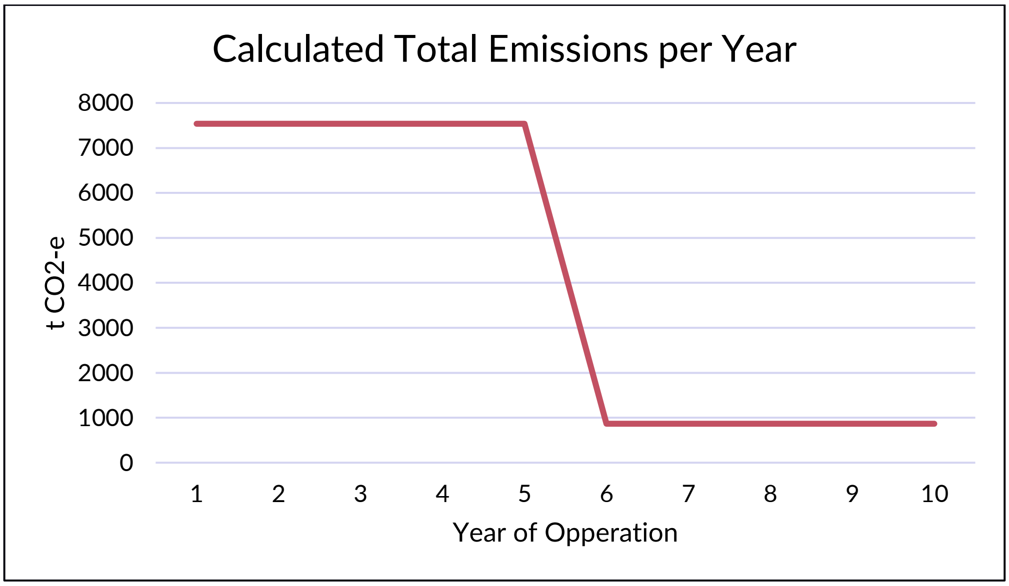


Figure 2-13: Total $CO_{2\text{-}e}$ *per* Year of the Project

All graphed emissions above fall within the scope 1 (direct) greenhouse gas emissions classification and were obtained using the NGER Emissions and Energy Threshold Calculator provided on the Clean Energy Regulator webpage (2020). The above figures were derived from the expected hydrocarbon consumption rate of equipment onsite, with the highest volume of emissions occurring in the first 5 years during the major construction and earthmoving phase of the project. In the subsequent 5 years post construction there is expected to be a significant reduction in consumption with generators and water pumps onsite contributing to the highest consumption rates in this stage. The average emission rate per year was calculated as 7538.36 t $CO_2$-e in the first 5 years and reduced to 866 t $CO_2$-e in the following 5 years. There are no expected scope 2 emissions for this project as power required for site offices will be provided by onsite generators included in the above calculations.

A total of approximately 11 ha of native vegetation clearing is expected across the entire project in order to excavate borrow materials and make way for the construction of the new WSF. Vegetation cleared in this area will be recycled within the revegetation system as either directly placed revegetation growth media, nursery production compost or sediment control layers. In addition to the planned revegetation of the 11 ha of cleared land there will be approximately 145 ha of land previously cleared, disturbed, or new land forms that will also be revegetated. This additional revegetation process is further discussed in Chapter 7 of the EIS.

## 2.6.5. Emergency Management

Emergency management practices will need to be implemented across site to minimise the risk to people, property and the environment as outlined within the *Risk Register* (GHD, 2019f – see Appendix). Developed EMPs will encompass the objectives, risks, performance criteria, emergency preparedness, mitigation and reporting requirements relating to the project. EMPs will be developed in line with the applicable legislation outlined in Chapter 3 – Compliance and Risk.

Existing local emergency services will need to be supplemented with additional project resources including an operational first aid station, fire response equipment, potential road accident rescue equipment and fully trained personnel. In all cases, the project will establish links with existing services to supplement response capabilities locally and support existing services. This includes links with Browns Oxide Mine.

## 2.7. References


Department of Primary Industry and Resources (2019) *Draft Water Management Plan, Stage 3 Rum Jungle Rehabilitation Project*.

GHD (2019e) *Social and Economic Impact Assessment, Rum Jungle Rehabilitation Project Report,* Report to the Department of Primary Industry and Resources, Northern Territory.

GHD (2019f) *Rum Jungle Stage 3 EIS Risk Register* – Rum Jungle Project Team.

Northern Territory Environment Protection Authority (2015) *Waste Management Strategy for the Northern Territory 2015-2022*, Northern Territory Environment Protection Authority, Darwin. [Online] Available at: https://ntepa.nt.gov.au/__data/assets/pdf_file/0008/284948/ntepa_waste_strategy_2015_2022.pdf [Accessed 22 November 2019].

Standards Australia (2006) *Steel tanks for flammable and combustible liquids*, AS 1692-2006, Standards Australia, NSW.

Standards Australia (2017) *Storage and handling of flammable and combustible liquids,* AS 1940:2017, Standards Australia, NSW.

Standards Australia (2017) *The storage and handling of mixed classes of dangerous goods, in packages and intermediate bulk containers,* AS/NZS 3833-2007, Standards Australia, NSW.

Standards Australia (2019) *Storage and handling of flammable and combustible liquids,* AS 1940:2017/Amdt 1:2019, Standards Australia, NSW.


## 2.8. References included in Appendix


Department of Primary Industry and Resources (2019) *Draft Water Management Plan, Stage 3 Rum Jungle Rehabilitation Project*.

GHD (2019e) *Social and Economic Impact Assessment, Rum Jungle Rehabilitation Project Report,* Report to the Department of Primary Industry and Resources, Northern Territory.

GHD (2019f) *Rum Jungle Stage 3 EIS Risk Register* – Rum Jungle Project Team.

# 3. Compliance and Risk

# Figures

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## 3.1. Legislative Framework

NT and Commonwealth legislation which may be applicable to the project is detailed within Table 3-1.

### 3.1.1. Approvals and Agreements

The primary approvals for the project will be *via* the EIS mechanism. However, additional approvals and agreements likely to be required for project implementation are detailed below.

Authority Certificate: there are several sacred sites at the Rum Jungle property therefore an Authority Certificate under the *Northern Territory Aboriginal Sacred Sites Act 1989* (NT) is required for Stage 3 works.

Approval to discharge: it is likely that treated water will be required to be discharged throughout the Stage 3 works. As a result, a Waste Discharge Licence (WDL) is likely to be required under the *Water Act 1992* (NT). The WDL will detail quantity and quality of water to be discharged, and associated conditions such as monitoring and reporting.

Approval to abstract groundwater: while groundwater abstraction will be for the treatment of AMD-impacted groundwater, it is likely that an exemption will be required under the Water Act.

Agreement for the use of low permeability material: low permeability material is located on land owned by CCGC. As a result, its agreement, including final land use will be required prior to implementation of the project. The instrument of agreement is yet to be determined.

Agreement for the use of granular material: as the granular material is located on the FRALT, a section 19 Land Use Agreement (LUA) is required under ALRA. The LUA process provides Traditional Owners the opportunity to consider, develop terms and conditions, and the right to consent to or reject proposals on their land and seas (NLC, 2019).

Potential approval for WSF: pursuant to the *Waste Management and Pollution Control Act 1998* (NT) either an Environmental Protection Approval (EPA) or Environmental Protection Licence (EPL) may be required for the proposed WSF.

Agreement for land access and rehabilitation: Mt Burton works are planned to take place on privately held land therefore an agreement for access and rehabilitation of the land will be required to ensure that works are carried out with respect to the land owner's instructions and to protect public safety during these works.

Land Clearing Permit: Land Clearing Permit: pursuant to the *Planning Act 1999* a Land Clearing Permit may be required for unzoned lanned such as the proposed borrow pit locaitons on the properties belonging to FRALT and CCGC as described in this document.

Table 3-1: Applicable legislation

| **Legislation** | **Project Relevance** |
|---|---|
| *Environmental Assessment Act (NT) and Administrative Procedures 1982 (NT)* | EIS required is accordance with the ToR and Statements of Reasons. |
| *Environment Protection Act 2019 (NT)* | The Act provides for an updated Environmental Impact Assessment process and establishes that an environmental approval must be granted by the relevant Minister before a proposal can proceed. The environmental approval may require certain matters to be reported and/or made public to improve transparency in to environmental impacts and the outcomes of actions. The Proponent (and the NT Department of Environment and Natural Resources (DENR)) anticipate that Part 14 transitional arrangements will apply to the Rum Jungle Rehabilitation Project upon this Act's commencement. |
| *Environment Protection and Biodiversity Conservation Act 1999* (Cth) | The delegate of the Australian Government Minister decided the proposed action is a controlled action, requiring assessment and approval under the EPBC Act before it can proceed. The relevant controlling provisions are: (i) listed threatened species and communities (sections 18 & 18A) and (ii) protection of the environment from nuclear actions (sections 21 & 22A). |
| *Aboriginal Land Rights (Northern Territory) Act 1976* (Cth) | The Act governs the grant and administration of Aboriginal land in the NT and, as a result, will be key legislation for resolving the Land Claim. Relevant Act for the section 19 Land Use Agreement (LUA) for borrow materials. |
| *Mineral Titles Act 2010* (NT) | The Act establishes a framework for the granting and regulation of mineral titles for the exploration and extraction of minerals and extractive minerals. Based on proposed activities, and the historic nature of the mining activities, it is the Proponent's view that no mineral title is required for components of the former Rum Jungle Uranium Field. It is likely that a mineral title will apply to the two borrow locations on CCGC land and the FRALT respectively. |
| *Mining Management Act 2001* (NT) | This Act governs the development of the NT's mineral resources in accordance with environmental standards to protect the environment. This Act may apply and the Proponent proposes to seek an exemption under section 7. Additionally, under section 83 the Minister may cause action to rehabilitate a mining site, authorising a person to undertake those works. |
| *Northern Territory Aboriginal Sacred Sites Act 1989* (NT) | Authority Certificate required for all activities undertaken in Stage 3 but will be especially relevant for works within sacred sites restricted work areas. |
| *Heritage Act 2011* (NT) | Provides a system for the identification, assessment, protection and conservation of the NT's natural and cultural heritage. If any archaeological places or objects are to be disturbed, permission must be sought to carry out work on a heritage place or object. Further details provided Chapter 8 - Historic and Cultural Heritage. |
| *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* (Cth) | Assists in the preservation and protection of Indigenous heritage. Further details provided Chapter 8 - Historic and Cultural Heritage. |
| *Water Act 1992* (NT) *and Water Legislation Miscellaneous Amendments Act 2019* (NT) | It is likely that a WDL will be required. In addition, groundwater abstraction for treatment will likely require approval. |
| *Bushfires Management Act 2016* (NT) | Established to prevent and supress bushfires. Further details provided Chapter 6 - Existing Environmental Condition. |
| *Soil Conservation and Land Utilisation Act 1969* (NT) | Provides for the prevention of soil erosion and requires an Erosion and Sediment Control Plan (ESPC). |
| *Weeds Management Act 2001* (NT) | Describes obligations of land owners to ensure listed species are not introduced and do not spread. |
| *Territory Parks and Wildlife Conservation Act 1976* (NT) | Permit to take or interfere with wildlife that is threatened. Threatened species have not identified, so permit is unlikely to be required. Further details provided Chapter 6 - Existing Environmental Condition and Chapter 14 - Terrestrial Flora and Fauna. |
| *Waste Management and Pollution Control Act 1998* (NT) | Environmental Protection Approval or Licence (EPA or EPL) likely to be required for WSF. |

| | |
|---|---|
| *National Greenhouse and Energy Reporting Act 2007* (Cth) | Requirements for controlling and reporting greenhouse gas (GHG) emissions. Further details provided in Chapter 6 - Existing Environmental Condition. |
| *Planning Act 1999* (NT) | Applicable for land clearing permits on freehold unzoned land such as the proposed borrow pits. |
| *Public and Environmental Health Act 2011* (NT) | May be applicable for sewerage systems and greywater originating from site ablutions. |
| *Traffic Act 1987* (NT) | Requires consent to erect or modify traffic control devices. Likely to be relevant for traffic control. |
| *Control of Roads Act 1953* (NT) | Works to upgrade the site intersection will be within the road reserve. Details of these works are provided in this EIS and the NTG has been engaged. Permits will be obtained prior to commencement of works. |
| *Dangerous Goods Act 1998* (NT) | The movement and handling of fuel is governed by this Act. This will be relevant for diesel provision to the project. |
| *Transport of Dangerous Goods by Road and Rail (National Uniform Legislation) Act 2010* (NT) and Transport of Dangerous Goods by Road and Rail (National Uniform Legislation) Regulations 2011 (NT) | The movement and handling of chemicals outside of workplaces is governed by the *Transport of Dangerous Goods by Road and Rail (National Uniform Legislation) Act 2010* (TDG Act) and the Transport of Dangerous Goods by Road and Rail (National Uniform Legislation) Regulations 2011 (TDG Regulations). This will be relevant for diesel provision to the project. |
| *Work Health and Safety (National Uniform Legislation) Act 2011* (NT) and Work Health and Safety (National Uniform Legislation) Regulations 2011 (NT) | The *Work Health and Safety (National Uniform Legislation) Act 2011* (WHS Act) and Work Health and Safety (National Uniform Legislation) Regulations 2011 (WHS Regulations) regulates health and safety in the workplace. Will be applicable for all works associated with the project. Further details provided in Chapter 15 - Human Health and Safety. |
| *Radiation Protection Act 2004* (NT) | Describes obligations relating to handling radiation sources. Further details provided Chapter 16 - Radiation. |
| *Australian Radiation Protection and Nuclear Safety Act 1998* (Cth) | Established the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) to regulate Commonwealth activities that raise radiation protection or nuclear safety concerns. Develops standards, codes of practice and guidelines for radiation protection and management. Further details provided Chapter 16 - Radiation. |
| *Atomic Energy Act 1953* (Cth) | Vests ownership in the Commonwealth of prescribed substances located in the NT. Prescribed substances are uranium, thorium and similar radioactive substances including associated derivatives or compounds, or otherwise as prescribed by regulation. May be applicable to new WSF. Further details provided Chapter 16 - Radiation. |

The following legislation is considered to not be applicable to the project:

- *Native Title Act 1993* (Cth) – a search of the National Native Title Tribunal's Register of Native Title Claims on 12 November 2019 indicated no native title determinations or applications over the project area.

## 3.2. Applicable Standards

Applicable standards are summarised below but also referenced in relevant Chapters:

- AS 1940:2017 – The storage and handling of flammable and combustible liquids (Standards Australia, 2017)
- AS 1940:2017/AMDT 1:2019 – The storage and handling of flammable and combustible liquids (Standards Australia, 2019)
- AS 1692-2006 – Steel tanks for flammable and combustible liquids (Australian Standards, 2006)
- AS/NZS 3833-2007 – The storage and handling of mixed classes of dangerous goods, in packages and intermediate bulk containers (Standards Australia, 2007)
- AS/NZS 1546.1-2008 – On-site domestic wastewater treatment units – Septic tanks (Standards Australia, 2008)

- AS/NZS 5667.11:1998 – Water quality - Sampling - Guidance on the Design of Sampling Programs, Sampling Techniques and the Preservation and Handling of Samples (Standards Australia, 1998)
- AS/NZS 45001:2018 - Occupational health and safety management systems – Requirements with guidance for use (Standards Australia, 2018)
- AS/NZS ISO 31000-2018 - Risk management – Guidelines (Standards Australia, 2018)
- SA SNZ HB 436-2013 - Risk Management guidelines - Companion to AS/NZS ISO 31000:2009 (Standards Australia, 2013).

## 3.3. Applicable Guidelines

Policy and guidelines relevant to assessment of impacts to the NT EPA's environmental factors are referenced in the relevant EIS Chapters where applicable. A summary of key guidelines are also detailed below:

- A Guide to Leading Practice Sustainable Development in Mining (Australian Centre for Sustainable Mining Practices, 2011)
- Environmental Assessment Guidelines on Acid and Metalliferous Drainage (NT EPA, 2013)
- Preventing Acid and Metalliferous Drainage – Leading Practice Sustainable Development Program for the Mining Industry (Department of Foreign Affairs and Trade, 2016)
- Best Practice Erosion and Sediment Control (International Erosion Control Association, 2008)
- Airborne Contaminants, Noise and Vibration – Leading Practice Sustainable Development Program for the Mining Industry (Department of Foreign Affairs and Trade, 2009)
- Water Accounting Framework for the Australian Minerals Industry (Minerals Council of Australia, 2014)
- Water Stewardship – Leading Practice Sustainable Development Program for the Mining Industry (Department of Foreign Affairs and Trade, 2016a)
- Mine Rehabilitation – Leading Practice Sustainable Development Program for the Mining Industry (Department of Foreign Affairs and Trade, 2016b).
- Mine Closure – Leading Practice Sustainable Development Program for the Mining Industry (Department of Foreign Affairs and Trade, 2016c)
- A Framework for Developing Mine-Site Completion Criteria in Western Australia (Western Australian Biodiversity Science Institute, 2019).

## 3.4. Project Risk Assessment

This section of the EIS describes the risk identification and assessment process undertaken by the Proponent for the Rum Jungle Rehabilitation Project. Risks associated with the project have been compiled into a *Risk Register* (GHD, 2019f – see Appendix). The Risk Register takes a whole-project-approach and incorporates all relevant project domains and phases of activity. For each project stage the Proponent has identified and assessed the potential risks that could impact the wider social and natural environment. These include the environment (air, land, surface and groundwater, and biodiversity), regulatory or compliance risks, community and stakeholder (economic, social and cultural heritage), human health and financial. The Proponent implemented a series risk identification and assessment workshops from 2018 to 2019 to identify, assess and review project risks, a process that has been refined by the results of the supporting technical study programs. A number of the Chapters within this EIS provide supporting information that has helped inform the risk identification and assessment process presented below.

The Rum Jungle Rehabilitation risk management framework has been developed from ISO31000 processes. The risk assessment process was iterative and included a number of workshops involving technical specialists over a two year period in order to adequately identify and assess the project risks, this process incorporated the following steps:

- Risk identification;
- Risk definition;
- Timeframe definition;
- Likelihood definition;
- Consequence definition;
- Level of confidence definition; and

- Key assumptions.

These steps are further described below. The results of this risk assessment process will form the foundation of a full Health, Safety and Environment Management System for the Stage 3 project works.

## 3.4.1. Risk Identification

A schedule of the project risks was initially compiled by the project team and refined over the course of several workshops in conjunction with supporting evidence from specialist technical studies. This refinement process included:

- A thorough review of risks previously identified in workshops to assess their applicability following additional information gained from technical studies
- The incorporation of additional identified risks by the project team as a result of the risk review workshop findings, through continued community and stakeholder consultation, and the incorporation of risks identified by third parties.

## 3.4.2. Risk Definition

The risk definition process included the assessment of each individual risk and the inherent (pre-project) and residual (post-project) risk. A combination of the consequences of failure and the likelihood of occurrence was considered for each risk event. This approach has enabled the Proponent to develop an analysis technique that is suitable to assess the potential for (or likelihood of) failure of processes, structures or equipment. An evaluation was performed on the effects of failure for each risk considering the aspects of the broader system including:

- Environmental;
- Community and stakeholder;
- Health and safety;
- Regulatory; and
- Financial aspects.

Failure was defined as any component of the project design which did not meet the specific rehabilitation objectives or meet performance expectations. The term 'risk' incorporated both the severity of the consequences of failure and the likelihood of occurrence, and feed directly into the Risk Matrix (Table 3-2).

Table 3-2: Risk Matrix

| Likelihood | Consequence Level | | | | |
|---|---|---|---|---|---|
| | Minor | Medium | Serious | Major | Catastrophic |
| Almost Certain | Medium | High | High | Extreme | Extreme |
| Likely | Medium | Medium | High | High | Extreme |
| Possible | Low | Medium | Medium | High | High |
| Unlikely | Low | Low | Medium | Medium | High |
| Rare | Low | Low | Low | Medium | Medium |
| Extreme | Intolerable - Risk reduction is mandatory wherever practicable. Residual risk can only be accepted if endorsed by senior management | | | | |
| High | Intolerable or tolerable if managed to as low as reasonably practicable - Senior management accountability | | | | |
| Medium | Intolerable or tolerable if managed to as low as reasonably practicable - Management responsibility | | | | |
| Low | Tolerable - Maintain systematic controls and monitor | | | | |

The process of risk analysis is imprecise, it involves the examination of events that have not yet occurred and attempting to foresee and mitigate future events. Due to the imprecise nature of risk assessment there were uncertainties around the frequency and consequences of particular risks; by identifying these uncertainties the Proponent was able to take steps to reduce these to acceptable levels. To achieve these reductions in uncertainty the scope of specialist technical studies were refined and redirected to address knowledge gaps followed by a subsequent reassessment of the relating risks.

### 3.4.3. Timeframe Definition

For each identified risk the effective timeframe of potential impact was defined. There were three defined classifications for the effective time periods of which identified risks could occur:

- Stage 3 (the construction period – up to 15 years)
- Stage 4 (post-rehabilitation short-term – up to 20 years)
- Stage 5 (post-rehabilitation long-term – > 20 years).

The expected effective timeframes for each risk is assigned in the *Risk Register* (GHD, 2019f – see Appendix).

### 3.4.4. Likelihood Definition

A quantitative approach was implemented for the analysis of the likelihood of risks (Table 3-3) with the chance of occurrence linked to the timeframe in which each risk could occur. When assigning likelihood descriptors the probability of the maximum credible consequence, assuming the specified planned controls are in place and are operating at their expected level of performance, is taken into account. The adequacy of the specified controls to manage the risk was also considered when assigning likelihood descriptors.

Table 3-3: Likelihood Descriptors

| **Likelihood Descriptors** | |
|---|---|
| **Descriptor** | **Explanation** |
| Almost Certain | The event is expected to occur in most circumstances<br>This event could occur at least once during a project of this nature<br>91-100% chance of occurring during the project |
| Likely | The event will probably occur in most circumstances<br>This event could occur up to once during a project of this nature<br>51-90% chance of occurring during the project |
| Possible | The event could occur but not expected<br>This event could occur up to once every 10 projects of this nature<br>11-50% chance of occurring during the project |
| Unlikely | The event could occur but is improbable<br>This event could occur up to once every 10-100 projects of this nature<br>1-10% chance of occurring during the project |
| Rare | The event may occur only in exceptional circumstances<br>This event is not expected to occur except under exceptional circumstances (up to once every 100 projects of this nature)<br>Less than 1% chance of occurring during the project |

### 3.4.5. Consequence Definition

The consequences of specific risks were assessed based on an elevation of expected responses following failure. The consequences of these failures were considered to have potential impacts to one or more factors: health, safety, onsite environment, off-site environment, cultural heritage, socio-economic, terrestrial flora and fauna, and aquatic ecosystems. The Criteria pertaining to the assessment of the severity of consequences specific to this project were developed during the Risk Register workshops and again during the risk review workshop. Consequence descriptors have taken into account both the category of impact and the potential severity. While a generic table of descriptors was developed (Table 3-4) during the workshops, specialists were advised to use their professional experience and knowledge to assign a final consequence level.

Table 3-4: Consequence Descriptors and Definitions

| **Consequence Descriptors** | | | | | |
|---|---|---|---|---|---|
| ***Category of Impact*** | ***Minor*** | ***Moderate*** | ***Serious*** | ***Major*** | ***Catastrophic*** |
| ***Health*** | Reversible health effects of little concern<br>First aid treatment | Reversible health effects of concern<br>Medical treatment | Severe reversible health effects of concern<br>Lost time illness | Single fatality or irreversible health effects or disabling illness | Multiple fatalities or serious disabling illness to multiple people |
| ***Safety*** | Low level short-term subjective inconvenience or symptoms<br>First aid treatment | Reversible injuries requiring treatment, but does not lead to restricted duties<br>Medical treatment | Reversible injury or moderate irreversible damage or impairment to one or more persons<br>Lost time injury | Severe irreversible damage or severe impairment to one or more persons | One or multiple fatalities or permanent damage to multiple people |
| ***Onsite Environment*** | Near-source confined and promptly reversible impacts<br>(Typically a shift) | Near-source confined and short-term reversible impact<br>(Typically a week) | Near-source confined and medium-term recovery impact<br>(Typically a month) | Impact that is unconfined and requiring long-term recovery, leaving residual damage<br>(Typically years) | Impact that is widespread unconfined and requiring long-term recovery, leaving major residual damage<br>(Typically years) |
| ***Off-site Environment*** | Not applicable | Near-source confined and promptly reversible impact.<br>(Typically a shift) | Near-source confined and short-term reversible impact.<br>(Typically a month) | Near-source confined and medium-term recovery impact<br>(Typically a month) | Impact that is unconfined and requiring long-term recovery, leaving residual damage<br>(Typically years) |
| ***Socio-economic*** | Local, small scale, easily reversible change on social characteristics or values of the communities of interest or communities can easily adopt or cope with change | Short-term recoverable changes to social characteristics and values of the communities of interest or community has substantial capacity to adapt and cope with change | Medium-term recoverable changes to social characteristics and values of the communities of interest or community has substantial capacity to adapt and cope with change | Long-term recoverable changes to social characteristics and values of the communities of interest or community has substantial capacity to adapt and cope with change | Irreversible changes to social characteristics and values of the communities of interest or community has substantial capacity to adapt and cope with change |
| ***Cultural Heritage*** | Reparable damage to site or item of low cultural significance | Irreparable damage to site or item of low cultural significance | Repairable damage to site or item of cultural significance | Irreparable damage to site or item of cultural significance | Irreparable damage to site or item of international cultural significance |
| ****Terrestrial flora & fauna*** | Localised (less than a hectare) and/or brief (days) | Small scale (few hectares) and/or short-term (weeks) | Medium scale (many hectares) and/or medium-term (months) | Large scale (many square kilometres) and/or long-term (years) | Regional and/or permanent, resulting in the dominance of only a few species |
| ****Aquatic ecosystems*** | Confined and/or brief (days) | Small scale (limited to watercourse within the project area) and/or short-term (weeks) | Medium scale (few kilometres downstream) hectares) and/or medium-term (months) | Large scale (many kilometres downstream) and/or long-term (years) | Regional and/or permanent, resulting in the dominance of only a few species |

**As measured by abundance and/or abundance and/or diversity of species, and cognisant of the existing condition of the ecosystem.*

### 3.4.6. Profile

The full table of identified project risks, including the risk ratings, descriptions and mitigation/management procedures, is available within the *Risk Register* (GHD, 2019f – see Appendix). Based on the results as presented in the Risk Register and in the figures below a total of 138 initial risks were identified with 59 (43%) classified as High and 11 (8%) as Extreme (Figure 3-1). The adoption of mitigation measures as proposed within this EIS and the Risk Register result in a significant shift in the risk profile (Figure 3-2) - the residual risks have been reduced to zero classified as Extreme, one as High, and the remainder reduced to Medium (43%) or Low (56%).

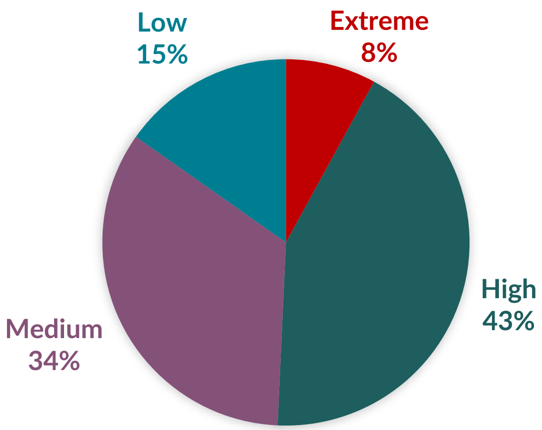


Figure 3-1: Initial Risk Ratings Profile

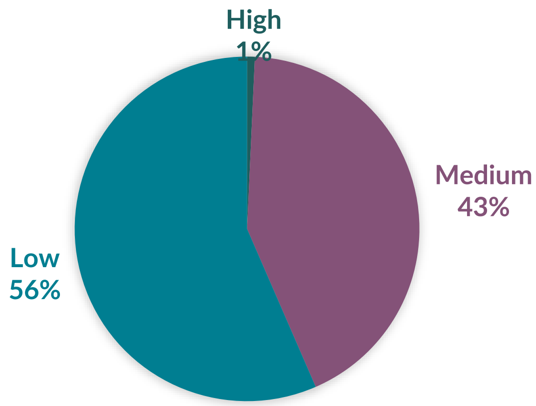


Figure 3-2: Residual Risk Ratings Profile

## 3.5. References

GHD (2019f) *Rum Jungle Stage 3 EIS Risk Register* – Rum Jungle Project Team.

Northern Land Council (2019) *Section 19 Land Use Agreements*. [Online] Available at: https://www.nlc.org.au/our-land-sea/aboriginal-land-legislation.

## 3.6. References included in Appendix

GHD (2019f) *Rum Jungle Stage 3 EIS Risk Register* – Rum Jungle Project Team.

# 4. Stakeholder Engagement and Consultation

# Tables

Table 4-1: EIS Stakeholder Analysis Matrix – IAP2 Elements ....4-4
Table 4-2: Stakeholder Formal Engagement Register ....4-5

## 4.1. Introduction

The NTG, *via* the Department of Primary Industry and Resources, has sought meaningful engagement from the early stages of the Rum Jungle Rehabilitation Project with a long-term objective to achieve overall positive outcomes for the community and stakeholders. The Proponent has taken a proactive approach to engagement activities to facilitate and accomplish participation amongst stakeholders to ensure those who will be affected by decisions are involved in the decision-making process. Stakeholder engagement activities have been heavily guided by the International Association for Public Participation's (IAP2) *Quality Assurance Standard Guidelines for Community and Stakeholder Engagement* (2015) and as such an emphasis has been placed on promoting sustainable decisions by recognising both the needs and interests of the community.

The current environmental impact of the former Rum Jungle mining complex is felt both onsite and downstream and the project objectives are both environmental and social in nature. Additionally, the project may provide future opportunities for key stakeholders and as such, a broad engagement and consultation program has been carried out since project inception in 2008. Generally, the range of stakeholders has included Traditional Owners, the CCGC, downstream water users, Coomalie public, and Territory and Commonwealth regulators amongst others. The style of engagement has evolved over time and key features have included the Rum Jungle Liaison Committee, NLC facilitated Local Descent Group (LDG) meetings and downstream impact assessment teams. Details are summarised below.

### 4.1.1. Stakeholder Engagement Objectives

In more recent consultation activities, the purpose and objectives of stakeholder engagement has been set with a focus on environmental rehabilitation, advancing the likelihood of resolution of the Land Claim as well as maximising the positive project benefits. The improvement of site conditions to restore cultural values as far as possible and support future progress of the Finniss River Land Claim over the Rum Jungle site has been a key aspect of the project design and as such has been set as a high priority when engaging with stakeholders. Stakeholder engagement has heavily focused on communicating the project objectives as outlined in Chapter 1 - Introduction (Section 1.2.1 Summary of Project Objectives) and utilising stakeholder feedback to inform the project design.

Engagement has also focused on communication with stakeholders to provide information on project developments, address major concerns and to seek collaboration. Engagement activities have allowed the Proponent to build a relationship with stakeholders and in turn gather information that has informed aspects of the project design, operation and closure. The knowledge gained from stakeholder engagement has injected the project with aspects that support stakeholder's short- and long-term interests and needs. The Proponent has aimed to work with the community to understand and reduce risks identified and maximise positive outcomes which has supported the development of the *SEIA* (GHD, 2019e, see Appendix).

### 4.1.2. Stakeholder Engagement Levels

The level and style of stakeholder engagement has varied both throughout the multiple stages of the project timeline and between stakeholder groups depending on the identified level of stakeholder interest in the project. Early stages of consultation aimed to provide the public with objective and balanced information whilst listening to the concerns raised by the various stakeholder groups and developing the project proposal in line with that feedback. The Proponent has aimed for a high level of public participation by collaborating with the identified key stakeholder groups and seeking advice and implementing feedback to the maximum possible extent. This has enabled the Proponent to involve and collaborate with not only the key stakeholder groups but all stakeholders at the appropriate levels.

### 4.1.3. Stakeholder Analysis Matrix

In line with the NT EPA guidelines for proponents, a stakeholder analysis matrix has been developed to ensure all stakeholders who will be directly or indirectly affected by the proposal, who have an interest or stake in the outcome, or have the ability to influence the outcome have been identified. The matrix has enabled the Proponent to identify the stakeholders that will be most affected by the economic, social, and environmental impacts, and has formed the engagement strategy to engage with these key groups. The stakeholder analysis has also enabled the Proponent to identify key issues that are likely to be significant to stakeholders and address them as effectively and early as possible. Details of the key stakeholders and the breakdown of the levels of interest of each group are available in Table 4-1.

### 4.1.4. Stakeholder Engagement Strategy

The Proponent recognises that stakeholder consultation and engagement, both formal and informal, provides opportunities for improvement and consequently aims to maximise engagement opportunities with not only the key stakeholders but all stakeholders in the community. It is also recognised that engagement strategies must be tailored to each stakeholder group so that the stakeholders themselves are placed in the best possible position and are adequately equipped and informed. The stakeholder engagement strategy incorporates the requirements for the three project deliverables and aims to provide the opportunity to maximise the project positive outcomes.

The stakeholder engagement styles over the project timeline have evolved and have enabled the Proponent to engage and collaborate with the multiple stakeholder groups. A variety of engagement strategies have been developed over the course of the eleven year consultation process to ensure cultural sensitivity and maximise participation in the community. Engagement has also focused on open dialog and active listening to key themes and concerns raised to enable the Proponent to adequately meet stakeholder expectations and inform project decision making. Key guidance documents used to develop the Engagement Strategy include the NTG's *Remote Engagement and Coordination Strategy* (2016) and the NT EPA's *Guidance for Proponents – Stakeholder Engagement* (2019).

## 4.2. Engagement Summary

To date there have been various opportunities for open channels of communication between the Proponent and stakeholders. The project has documented around 100 formal engagement events and this is not inclusive of informal interactions, enquiries and daily engagement with stakeholders in project development. Stakeholder engagement has been incorporated in the project from the early stages of Stage 1 in 2008 through to Stage 2A in 2019, and included a wide cross-section of stakeholder in the community; a detailed register of communications is available in Table 4-2. With increasing stakeholder engagement as the project developed an Engagement Framework was developed outlining detailed and planned engagement into the future. Stakeholder engagement is to continue into Stages 3 and 4 of the project to maintain open channels with all stakeholders.

Comments and concerns received during stakeholder engagement activities are assessed on a case-by-case merit basis to ensure that if the project has not already taken them into account, they are addressed at the appropriate level in design and assessment. Over the considerable number of stakeholder engagement opportunities that have taken place during Stages 1 to 2A, feedback received from stakeholders has altered the project directions, these are discussed in further detail under Section 4.3.

## 4.3. Key Themes

Throughout the consultation process several key recurring themes have been highlighted. These key themes have varying levels of impact and baring for the identified stakeholder groups but all are considered important and have driven and altered the project pathway. Key themes that have been addressed in the project plan are outlined in Sections 4.3.1 to 4.3.4, and additional themes are discussed in Section 4.3.5.

### 4.3.1. Environmental Themes

Improved quality in the EBFR and the Finniss River downstream is not only a significant component for this project proposal but has repeatedly been highlighted as a key theme in response to stakeholder engagement. Stakeholders have identified this as a particular area of concern and the project outcomes aim to address this as a one of the top priorities. In conjunction with improvement of the EBFR and Finniss River, downstream stakeholders have indicated that the rehabilitation of the land and return of the environmental quality is also of high concern. These two key themes are in line with the project aims of overall environmental rehabilitation by returning the site to a safe, stable, sustainable, and non-polluting condition and have in turn driven stakeholder engagement and interest in the project.

### 4.3.2. Cultural Themes

As one of the significant stakeholder groups, Traditional Owners have raised several recurring key themes that have driven and shaped the project planned outcomes. An important part of this has been the return of the flow and quality of water moving through the site and the end Land Use Plan (see Figure 6-8 or Figure 7-2) for the site. It is critical to the project that all engagement works are undertaken with an overarching principle that rehabilitation of the land and water, and improvement to cultural aspects of the site go hand in hand. This key theme is consistent with Traditional Owner's objectives for rehabilitation and post-rehabilitation land use (see Chapter 1 – Introduction, Section 1.4 Traditional Owners) and as such has driven the collaboration with this key stakeholder group with the aim to actualise these project outcomes.

### 4.3.3. Economic Themes

A key theme highlighted across multiple stakeholder groups is the potential economic benefit that the project can deliver at the local level. This has been expressed in the form of maximising opportunities for Traditional Owners and Coomalie stakeholder groups during and post construction and wherever possible. Concerns and key themes expressed during consultations with stakeholder groups have shaped the project proposal and as such the project delivery schedule now better reflects the economic interests and needs of stakeholder groups. Employment and training opportunities is seen as positive for both for the future of both the individual and the wider community, and has been are area of high importance to the project delivery. Additionally, it has been raised at several forums that the Stage 3 project needs to consider procurement policies that favour local economic development.

### 4.3.4. Key Project Themes

Feedback from stakeholder engagement has also highlighted stakeholders' interest and expectations in receiving up to date information on project developments including the Stage 3 timeline, governance and project delivery model. The Proponent has aimed to meet these expectations by delivering information to stakeholders in a way that facilitates clarity and inclusion for all stakeholder groups and fulfils the Proponent's duty to effectively engage with stakeholders. Stakeholder engagement has formed a key aspect of the project development and the continued input be stakeholders is a key theme looking towards the future project delivery.

## 4.4. Addressing Further Issues

Through the stakeholder consultations held to date several key themes discussed by stakeholders have highlighted the need for further action before project delivery can begin. These issues are the need to gain a section 19 Land Use Agreement of ALRA for the granular material borrow area, and an agreement instrument with CCGC for the low permeability material borrow. While these issues have not been completely resolved, the Proponent has taken the steps in engaging with the relevant stakeholders to attain the relevant agreements. The proponent is committed to working with stakeholders to reach an agreement that allows for the maximum possible positive outcome for all parties.

Consultation and engagement gaps have also been identified in recent times, this includes a need to improve engagement with downstream water users and improving the frequency of engagement in Coomalie public forums. These comments have been taken on board and plans are in place to improve this.

## 4.5. Future Stakeholder Engagement

While a large body of work has been done around stakeholder engagement, the continued participation and collaboration of stakeholders will form an essential aspect of the project delivery into the future. Collaboration with Traditional Owners is key in the future stakeholder engagement strategy. Comments made on the draft EIS during the public exhibition period will feed into the supplementary EIS and the project design and delivery. The Proponent holds a high regard for the involvement of stakeholders and aims to continue engagement activities to ensure the community is informed about progress and provided with the ongoing opportunity to provide feedback.

A Stage 3 Stakeholder Communication and Engagement Strategy, and supporting Plan, will be developed to support and continue the engagement process.

Table 4-1: EIS Stakeholder Analysis Matrix – IAP2 Elements

| | **Sacred Site Custodians** | **FRALT Traditional Owners** | **NTG—Direct Impacts** | **Private Landowners—Direct Impacts** | **CCGC** | **Local Business** | **Downstream Landowners** | **Academic Groups** | **NGOs** |
|---|---|---|---|---|---|---|---|---|---|
| **Purpose** | Establish agreed final landform for rehabilitation of sacred sites and adjacent landforms. | Due process *via* the NLC to ensure that project deliverables take into account TO objectives (to increase likelihood of Land Claim settlement). | Ensure efficient delivery of high quality EIS. Whole of Government approach to project delivery. | Establish agreed plans for landforms located on private property. | Improve awareness of project. Local Impact Assessment and Management Plan. | Improve awareness of project. SEIA and SEIMP input. | Improve awareness of project. SEIA and SEIMP input. | Improve awareness of project. SEIA and SEIMP input. | Improve awareness of project. SEIA and SEIMP input. |
| **Outcomes** | Gain AAPA Authority Certificate for landforms associated with Sacred Sites. | Maximum agreement on project deliverables. | Direct guidance over: EIS components (DENR, DCM), Indigenous Opportunity Plan (DTBI), Stage 3 delivery model (DIPL). | Maximum agreement on project deliverables. | Valuable input into Council level Impact Assessment and Management Plan. | Valuable input into the SEIA and SEIMP. | Improve awareness of project. SEIA and SEIMP input. | Improve awareness of project. SEIA and SEIMP input. | Improve awareness of project. SEIA and SEIMP input. |
| **Process** | Engage AAPA and consultant anthropologist to facilitate this process. | Formal NLC consults supplemented by DPIR led 'out of session' workshops. | Direct collaboration with individual officers within Departments. | 1 — Direct engagement meeting.<br>2 — Stakeholder Group meetings. | 1 — Direct engagement meeting.<br>2 — Stakeholder Group meetings. | Stakeholder Group meetings. | Stakeholder Group meetings. | Stakeholder Group meetings. | Stakeholder Group meetings. |
| **Decision Making Level** | Approval required for works under Authority Certificate for works. | Collaboration on negotiable components of the plan: weed management, Opportunity Plan, reveg. systems, Land Use Plan, s19 Land Use Agreement (granular borrow). | EIS Approval, Waste Discharge Licence, Traffic Management Approvals, Road upgrade approvals, AAPA Approvals, WSF approval | Collaboration on some negotiable components of the plan:<br>access to private property for rehabilitation activities. | No decision making role. | No decision making role. | No decision making role. | No decision making role. | No decision making role. |
| **Level of Interest** | High | High | High | High | High | High | Medium | Medium | Medium |
| **Level of influence** | Collaborate/ Empower | Involve/Collaborate | Collaborate/ Empower | Collaborate/ Empower | Consult | Inform/ Consult | Inform | Inform | Inform |

Table 4-2: Stakeholder Formal Engagement Register

| Date | Parties Involved | Topic |
|---|---|---|
| 12/08/2008 | Rum Jungle Working Group (RJWG) | Brief site history, National Partnership arrangement (NPA), MoU Department of Industry, Tourism and Resources and NT Department of Natural Resources Environment and The Arts (NRETA), Summary on review of historic data, Forward work plan |
| 18/11/2008 | RJWG | Summary on groundwater surveys, pit profiling, land management, Bush tucker |
| 17/03/2009 | RJWG | Various internal notes |
| 20/05/2009 | RJWG | Technical discussion on closure objectives, Site maintenance, Site visit summary, Groundwater survey discussion, Review of downstream data |
| 28/07/2009 | RJWG | Site work supervision planning, NPA discussions, Works planning |
| 20/08/2009 | RJWG | Various internal notes, Discussion around site radiological anomalies, Determination that NLC should be informed prior to anyone attending site so that Traditional Owners can be informed |
| 15/10/2009 | RJWG | Project update |
| 09/04/2010 | RJWG | Various internal notes, Traditional Owners requested the establishment of protocols for visitors to site (*via* NLC communication) |
| 04/05/2010 | RJWG, NLC, Traditional Owners | FRALT claim background, Discussion around the lack of involvement of TOs in the RJWG, Various internal notes |
| 14/07/2010 | RJWG | Various internal notes |
| 2/09/2010 | DoR, NLC, AAPA, RJ Custodians | Project discussion - actions to complete detailed soil and fluvial contamination assessment, and drilling of new monitoring bores |
| 19/09/2010 | NLC, Abrus Consulting, NT Department of Resources (DoR), Cth Department of Resources, Energy and Tourism (DRET), various Kungarakan and Warai Traditional Owners | Discussion around current site conditions, Raising of the EIS study, Discussion around future works planning |
| 10/10/2010 | RJWG | Groundwater studies updates, Aerial photo CDs distributed, Discussion around AAPA Authority Certificates, Summary on Darwin-Daly Regional Council update, Discussion on protocols for visitors to site |
| 23/11/2010 | DoR, CCGC | Project update, Raised Mt Burton and Mt Fitch sites |
| 25/11/2010 | Rum Jungle Advisory Stakeholder Group | Project update |
| 25/02/2011 | RJWG | Various internal notes |
| 26/03/2011 | Kungarakan and Warai Traditional Owners, DoR | Inaugural meeting of the Rum Jungle Traditional Aboriginal Owners Liaison Committee |
| 01/06/2011 | RJWG | Planning for field works, Various internal notes |
| 15/06/2011 | Rum Jungle Stakeholder Advisory Group (DoR, DRET, Amateur Fishing Association NT, Hunan Nonferrous Metals Corporation (HNC), CCGC, NT Seafood, NT EPA) | Project activities updates, Terms of Reference discussion |
| 25/06/2011 | Kungarakan and Warai Traditional Owners, DoR, Radiation Specialist | Meeting of the Rum Jungle Traditional Aboriginal Owners Rehabilitation Committee, Radiation Specialist presented on site radiation situation |
| 16/09/2011 | RJWG | Project update |
| 24/09/2011 | Kungarakan and Warai Traditional Owners, DoR, NLC | Meeting of the Rum Jungle Traditional Aboriginal Owners Rehabilitation Committee |
| 16/11/2011 | RJWG | Discussion around material movement from FRALT, Draft MoU between arrangement for consultation between Traditional Owners and DoR, RJ quarterly status report discussion |
| 09/12/2011 | RJWG | Approval for sampling on FRALT for cover design, Groundwater studies report circulation, Heritage report discussion, Discussion with Mt Fitch and Mt Burton about initial inspection of sites, Various internal notes |
| 17/12/2011 | Rum Jungle Liaison Committee | |
| 13/03/2012 | RJWG | Project update |
| 14/03/2012 | Rum Jungle Liaison Committee | Project update |
| 13/04/2012 | RJWG | Project update, Various internal notes |
| 14/04/2012 | Kungarakan and Warai Traditional Owners, DoR, NLC, DRET | Meeting of the Rum Jungle Traditional Aboriginal Owners Rehabilitation Committee, WRD discussions, Mineral licences, Weed management |
| 14/05/2012 | RJWG | Project update, Various internal notes, Commonwealth Minister's visit to RJ discussion |
| 18/05/2012 | DoR, DRET, Kungarakan and Warai Traditional Owners, Cth Minister for Resources and Energy | Then Minister Ferguson (and advisers) site visit and update; met with Traditional Owners |
| 08/06/2012 | RJWG | Project update |
| 09/06/2012 | Rum Jungle Liaison Committee | Project update |
| 15/06/2012 | RJWG | Site visit for approx. 60 delegates from International Atomic Energy Agency. Various internal notes, Project update, 2011 radiological assessment at Rum Jungle Creek South (RJCS) undertaken |
| 10/07/2012 | Rum Jungle Stakeholder Advisory Group (DoR, DRET, Amateur Fishing Association NT, HNC, CCGC, NT Seafood, Environment Centre NT (EC NT), NLC) | Rum Jungle mine update, NPA discussion, Additional sites added to NPA |
| 07/09/2012 | RJWG | Project update |

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|---|---|---|
| 03/10/2012 | DME, Rum Jungle Liaison Committee, Hydrobiology | Consultation to obtain Traditional Owner input for informing environmental values under ANZECC Guidelines 2000 |
| 01/11/2013 | DPIR | Newsletter to entire NT Government - project update |
| 23/11/2013 | NLC, Traditional Owners | Newsletter provided at NLC request for it to distribute |
| November 2013-June 2016 | Consultation Specialist, DIIS, Kungarakan and Warai representatives, relevant government (Cth, NT) agencies, various third parties | Identify traditional owner economic development aspirations and establish links to potential government/private programs and funding opportunities |
| 15/01/2014 | Department of Industry (DoI), Department of the Prime Minister and Cabinet (PMC) (Indigenous Affairs) (PMC) | Project update |
| 13/03/2014 | RJWG | Project update |
| 27/03/2014 | DME, Cth Department of the Environment (DoE) | Site visit; Project history and update |
| 01/07/2014 | DME, DoI, NLC, Consultation Specialist | Project update |
| 02/07/2014 | Rum Jungle Stakeholder Advisory Group (EC NT, MCA, Hunan Nonferrous Metals Corporation (Australia) Resources Pty Ltd (HAR), Coomalie Council, DME, DoI, Consultation Specialist) | Project update |
| 03/07/2014 | PMC, Jacobs, DoI, Consultation Specialist | Project discussion in terms of land use and grant under ALRA |
| 04/07/2014 | Rum Jungle Working Group (DME, NT EPA, Geochemistry Specialist, DoI, PMC, Jacobs, Nation Partners, Consultation Specialist) | Project Update, AAPA Authority Certificate update, Scope of field works, Pit profiling discussions |
| 05/07/2014 | Rum Jungle Traditional Owner Liaison Committee | Project update |
| 01/11/2014 | DPIR | Newsletter to entire NT Government - project update |
| 28/11/2014 | RJWG | DME update on Stage 2 activities, Rehabilitation planning, Detailed Business Case, Stakeholder discussions |
| 29/11/2014 | Rum Jungle Traditional Owner Liaison Committee (NLC, DME, Kungarakan and Warai Traditional Ownerss, DoI, Consultation Specialist) | Various discussions, Government procurement process, Q&A session, General project update |
| 20/03/2015 | RJWG | Update on Stage 2, Update on Detailed Business Case, Stakeholder consultation |
| 21/03/2015 | Rum Jungle Traditional Owner Liaison Committee (NLC, DME, Kungarakan and Warai Traditional Owners, Cth Department of Industry and Science, Consultation Specialist) | Various discussions, Government procurement process, Q&A session, General project update |
| 23/04/2015 | Rum Jungle Stakeholder Advisory Group (DME, MCA, EC NT, HAR) | Project update |
| 29/04/2015 | Hydrobiology, DME, DIIS, Consultation Specialist, White Eagle community members | Present findings of Downstream Ecosystem Impact Assessment to make Mak Maranungu representatives; discuss concerns |
| 30/05/2015 | Full Traditional Owner Meeting (DoR, DRET, NLC, SLR Consulting) | Proposed Land Use Zones (after rehabilitation) and request to access FRALT (adjacent to Woodcutters site) to investigate borrow materials potential |
| May-September 2015 | ECB Training Services, Kungarakan and Warai Traditional Owners | Skills matrix development |
| 02/06/2015 | ECB Training, Nation Partners, Consultation Specialist, DIIS | Socio-economic development plan consultation<br>Interested in training provider opportunities and noted barriers to successful Aboriginal contracting |
| 02/06/2015 | Warai Traditional Owners (15 Mile Community), Nation Partners, Consultation Specialist, DIIS | Socio-economic development plan consultation<br>Interested in obtaining socio-economic assistance and employment in works |
| 02/06/2015 | Territory Natural Resource Management (NRM), Nation Partners, Consultation Specialist, DIIS | Socio-economic development plan consultation<br>Provides land management training |
| 03/06/2015 | Kungarakan Traditional Owners, Nation Partners, Consultation Specialist, DIIS | Socio-economic development plan consultation<br>Employment/business opportunities identification during works |
| 03/06/2015 | Kungarakan Traditional Owners (Amangal Community), Nation Partners, Consultation Specialist, DIIS | Socio-economic development plan consultation<br>Employment/business opportunities identification (especially in NRM) |
| 03/06/2015 | CCGC, Nation Partners, Consultation Specialist, DIIS | Provided advice on baseline socio-economic conditions for area<br>Supportive of Traditional Owner public engagement activities as part of tourism opportunities |
| 03/06/2015 | Batchelor Institute of Indigenous Tertiary Education, Nation Partners, Consultation Specialist, DIIS | Socio-economic development plan consultation<br>Possibility for accreditation of works participation with concurrent course completion |
| 04/06/2015 | NT Department of Business, Nation Partners, Consultation Specialist, DIIS | Socio-economic development plan consultation<br>Emphasis on local Aboriginal employment participation; business development/support programs |
| 04/06/2015 | Indigenous Business Australia, Nation Partners, Consultation Specialist, DIIS | Socio-economic development plan consultation<br>Runs workshops to assist with establishing business readiness and facilitates access to financial support |
| 04/06/2015 | AusIndustry, Nation Partners, Consultation Specialist, DIIS | Socio-economic development plan consultation |

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| 05/06/2015 | PMC, Nation Partners, Consultation Specialist, DIIS | Socio-economic development plan consultation<br>Aboriginal development programs |
| 05/06/2015 | NLC, Nation Partners, Consultation Specialist, DIIS | Socio-economic development plan consultation |
| 05/06/2015 | Kungarakan TO, Nation Partners, Consultation Specialist | Socio-economic development plan consultation<br>Traditional Owner employment opportunity in works |
| 05/06/2015 | MCA, Nation Partners, Consultation Specialist | Socio-economic development plan consultation<br>Skills shortage particularly in rehabilitation; training opportunity for Traditional Owners to develop skills and capability |
| 22/08/2015 | Kungarakan and Warai Full Traditional Owner Meeting | Project update, Traditional Owner Liaison Meeting update, Hydrobiology update on downstream ecosystems, Waste Storage Facility (WSF) location update |
| 18/09/2015 | RJWG | Update on Stage 2, Cth update, Stakeholder consultation |
| 15/10/2015 | Rum Jungle Stakeholder Advisory Group | Project update |
| 16/10/2015 | NT Department of Lands, Planning and Environment, DME, DIIS | Project update, Land planning and management |
| 17/10/2015 | Kungarakan and Warai Full Traditional Owner Meeting | Project update, Discussion around WSF location, Gateway Review |
| 28/11/2015 | Kungarakan and Warai Full Traditional Owner Meeting | Summary on year's RJ work, NLC update, DME update |
| 5/04/2016 | RJWG | Update on Stage 2 investigations and design, Update on Detailed Business Case, Stakeholder consultation |
| 14/05/2016 | Kungarakan and Warai Full Traditional Owner Meeting | Various project related discussions about opportunity, tendering and equal opportunities between groups |
| 31/08/2016 | Rum Jungle Stakeholder Advisory Group (CCGC, NT Public Health Association of Australia (PHAA), NLC,NT Seafood Council, Consultation Specialist, DoI, DME) | Update on Stage 2A, Official inclusion of RJCS into budget, RJCS radiation assessment outcomes |
| 03/02/2018 | Kungarakan and Warai Full Traditional Owner Meeting | Project update |
| 19/03/2018 | DPIR, DIIS, NLC, Kungarakan and Warai Traditional Owners, Gateway Review Team | Project update and site visit |
| 02/05/2018 | DPIR, DIIS, NLC | Project update and planning |
| 17/05/2018 | NLC | Project overview |
| 01/06/2018 | NLC, DPIR, Kungarakan TO | Project update |
| 19/07/2018 | DPIR, NLC, GHD, Kungarakan Traditional Owners | Project update |
| 10/09/2018 | DPIR, Geochemistry Specialist, SLR, BG Group Engineers, University of Queensland, Earth Systems | Geochemical Workshop |
| 08/12/2018 | Kungarakan Aboriginal Corporation | Project update |
| 14-19/01/2019 | DPIR, DIIS, SLR, In Depth Archaeology, Consultation Specialist, Traditional Owners<br>Warai meeting 15 January 2019<br>Kungarakan (Stanton) meeting 16 January 2019<br>Kungarakan (McGregor/Verberg) meeting 17 January 2019<br>Kungarakan (McGuiness) meeting 19 January 2019 | Project update |
| 15/01/2019 | DIIS, EC NT | High level project update and (preliminary) identification of high interest issues |
| 18/01/2019 | DIIS, NT PHAA | High level project update and (preliminary) identification of high interest issues |
| 04/02/2019 | DoEE (including the Office of Water Science (OWS)), DPIR, DIIS | Kick off meeting – reintroduce project to new DoEE officers and discuss EIS project early |
| 05/02/2019 | AAPA, DPIR | Request for information from AAPA of sites within 3km radius of RJ site |
| 13/03/2019 | Warai Traditional Owners, NLC | NLC Meeting: Landform concept design update, WSF, Main Pit, Borrow pits, Upcoming field work |
| 15/03/2019 | Kungarakan Local Descent Group (LDG), NLC | NLC Meeting: Landform concept design update, WSF, Main Pit, Borrow pits, Upcoming field work |
| 16/03/2019 | Kungarakan LDG, NLC | NLC Meeting: Landform concept design update, WSF, Main Pit, Borrow pits, Upcoming field work |
| 21/03/2019 | NLC Anthropology | Trying to arrange Senior Warai men's meeting |
| 22/03/2019 | Newmont, NLC | Discussion on combined approach to Governance Framework |
| 26/03/2019 | Kungarakan LDG, NLC | Traditional Owners detailed information sharing on waste storage and pit rehabilitation strategies |
| 28/03/2019 | NT Department of the Chief Minister (DCM) | Project update and advice on social aspects of EIS |
| 29/03/2019 | Kungarakan LDG, DPIR | Instruction on inductions |
| 02/04/2019 | Kungarakan LDG, DPIR | Representative Traditional Owners walk over proposed borrow pit locations on FRALT |
| 03/04/2019 | Warai LDG, DPIR | Skills matrix development |
| 04/04/2019 | Kungarakan LDG, DPIR | Project update |
| 12/04/2019 | Kungarakan LDG, DPIR | Representative Traditional Owners walk over proposed borrow pit locations on FRALT |

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|---|---|---|
| 13/04/2019 | Kungarakan LDG, DPIR | Representative Traditional Owners walk over proposed borrow pit locations on FRALT |
| 13/04/2019 | Warai LDG, DPIR | Representative Traditional Owners walk over proposed borrow pit locations on FRALT |
| 29/04/2019 | Kungarakan Custodians, AAPA, NLC | AAPA consultation on Main Pit rehabilitation strategy |
| 29/04/2019 | Kungarakan Custodians, AAPA, NLC | AAPA consultation on Main Pit rehabilitation strategy |
| 30/04/2019 | Kungarakan Custodians, DPIR | Field visit regarding AAPA discussion for Main Pit |
| 02/05/2019 | Kungarakan Traditional Owners, DPIR | AAPA consultation on central landforms rehabilitation strategy |
| 04/05/2019 | Kungarakan Custodians, DPIR | Cairns meeting of this line of the Traditional Owner descent group to provide project update |
| 07/05/2019 | Kungarakan LDG, NLC, DPIR | NLC Meeting: Project update, Landforms, Approvals, AAPA for site, Field work on FRALT and on site |
| 08/05/2019 | NLC, DPIR, Kungarakan Traditional Owner | Distribution of cultural monitoring works for upcoming field works |
| 08/05/2019 | Kungarakan LDG, NLC, DPIR | NLC Meeting: Project update, Landforms, Approvals, AAPA for site, Field work on FRALT and on site |
| 08/05/2019 | Kungarakan and Warai | Attempting to contact family to provide information and updates *via* another family |
| 09/05/2019 | Warai Traditional Owners, NLC, DPIR | NLC Meeting: Project update, Landforms, Approvals, AAPA for site, Field work on FRALT and on site |
| 09/05/2019 | Finniss Reynolds Catchment Group | Update on RJ Project - good interest, questions about downstream impacts and weeds |
| 15/05/2019 | South Australia Legacy Mines Team | Lessons learned on Brukunga Project |
| 16/05/2019 | DPIR, GHD, DIIS, NT PHAA, DoEE (represented by Supervising Scientist Branch (SSB)), Territory Resources, NT EC, Environmental Defenders Office, Horizon Environmental Soil & Survey Evaluation | RJ Stakeholder Group Meeting - Overview of site history, Current rehabilitation plans, Cultural heritage and cultural views, Assessment timeframes |
| 16/05/2019 | CCGC Chief Executive Officer (CEO) | Use of Council land as RJ main site borrow |
| 24/05/2019 | CCGC CEO | Progression of soil test pitting works at the Council block at RJCS |
| 27/05/2019 | Kungarakan LDG | Various complaints received |
| 03/06/2019 | NTG | Whole of Government meeting to review interconnections of agency roles within the RJ Project |
| 04/06/2019 | NT EPA Board, DENR, DoEE (including OWS and SSB), DPIR, DIIS | NT EPA Board RJ site visit and QA/QC session on site |
| 06/06/2019 | CCGC CEO | Project update and advice on processes needed for any agreements or approvals for RJCS works or RJ Project |
| 11/06/2019 | Project Engineers and Advisors | Review of delivery options for Main Pit backfilling |
| 24/06/2019 | CCGC | Rum Jungle project update |
| 27/06/2019 | Traditional Owners - Warai and Kungarakan Land Use Panel | Panel meeting to develop Land Use Plan (draft) |
| 4/07/2019 | Warai Traditional Owners | Update on Land Use Plan and timeline |
| 5/07/2019 | Kungarakan Traditional Owners | Update Custodian on Land Use Plan and project status |
| 9/07/2019 | DPIR, DIIS, DoF, GHD | Project update and contaminated land considerations |
| 16/07/2019 | NLC, DPIR | Discussion as context for SEIA consultation |
| 17/07/2019 | Batchelor Public Meeting - AM session 18 people, PM session 16 people | Overview of project - various issues raised and discussed |
| 17/07/2019 | CCGC CEO | SEIA consultation - input on likely impacts of project |
| 17/07/2019 | Litchfield Motel and Rum Jungle Tavern Owner | SEIA consultation - input on likely impacts of project |
| 17/07/2019 | NT Police | SEIA consultation - input on likely impacts of project |
| 17/07/2019 | Batchelor Area School, Administrator | SEIA consultation - input on likely impacts of project |
| 18/07/2019 | RJ Stakeholder Group | Site visit and update on technical and cultural components of Project |
| 18/07/2019 | Batchelor Community Health Centre | SEIA consultation - input on likely impacts of project |
| 18/07/2019 | Cookes Tours and RS Gardening | SEIA consultation - input on likely impacts of project |
| 18/07/2019 | Local Resident | SEIA consultation - input on likely impacts of project |
| 19/07/2019 | Bushfires NT | SEIA consultation - input on likely impacts of project |
| 19/07/2019 | Kungarakan TO | SEIA consultation - input on likely impacts of project |
| 19/07/2019 | Warai Traditional Owners | SEIA consultation - input on likely impacts of project |
| 22/07/2019 | Parks and Wildlife NT | SEIA consultation - input on likely impacts of project |
| 22/07/2019 | Kungarakan Traditional Owners | SEIA consultation - input on likely impacts of project |
| 23/07/2019 | DIPL | SEIA consultation - input on likely impacts of project |
| 23/07/2019 | Kungarakan TO | SEIA consultation - input on likely impacts of project |
| 23/07/2019 | Litchfield Tourism Committee | SEIA consultation - input on likely impacts of project |
| 25/07/2019 | NT Department of Health, Radiation and Environment Health | SEIA consultation - input on likely impacts of project |
| 30/07/2019 | DENR, DIIS, DoEE (including OWS and SSB), RGC | Update technical assessment team on details of groundwater modelling works for the Project |
| 01/08/2019 | DENR, EcOz | Update on biodiversity field work and scope for EIS |
| 02/08/2019 | Ironbark Aboriginal Corporation | SEIA consultation - input on likely impacts of project |
| 08/08/2019 | Finniss Reynolds Catchment Group | Questions availability on Rum Jungle and EIS |

| | | |
|---|---|---|
| 12/08/2019 | Kungarakan and Warai Traditional Owners | NLC Meeting: Role of NLC, ALRA, Project update, Cultural heritage |
| 12/08/2019 | DIIS, NIAA | Update on design and consultation on draft Land Use Plan (in terms of ALRA) |
| 13/08/2019 | NT EPA Board, RGC, DENR, DPIR, DIIS | Present update to NT EPA Board meeting including groundwater findings |
| 19/08/2019 | Mt Burton landowner | Review of the rehabilitation works at Mt Burton |
| 19/08/2019 | Batchelor Institute of Indigenous Tertiary Education | SEIA consultation - input on likely impacts of project |
| 23/08/2019 | NT Assessment Forum | Present project and overview to Assessment Forum |
| 04/09/2019 | DENR, DoEE (represented by OWS and SSB), Hydrobiology, DPIR, DIIS | Update to assessment team regarding downstream ecosystem impact assessment and LDWQTVs |
| 08/10/2019 | CCGC - CEO and President | Formal email requesting meeting regarding use of Council land for borrow material. Updated on all work complete for that material - geotechnical, AAPA, cultural heritage, ecological survey. Formal request for meeting |
| 19/10/2019 | NLC, Kungarakan McGuinness LDG | Project update including EIS, RJCS, Engineering design, Final field works pre-EIS |
| 21/10/2019 | NLC, Warai LDG | Project update including EIS, RJCS, Engineering design, Final field works pre-EIS |
| 22/10/2019 | NLC, Kungarakan McGregor-Verberg LDG | Project Update including EIS, RJCS, Engineering design, Final field works pre-EIS |

## 4.6. References

GHD (2019e) *Social and Economic Impact Assessment, Rum Jungle Rehabilitation Project Report,* Report to the Department of Primary Industry and Resources, Northern Territory.

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Department of Housing and Community Development (DHCD) (2016) *Remote Engagement and Coordination Strategy*. [Online] Available at: https://dlghcd.nt.gov.au/__data/assets/pdf_file/0009/188523/REC-Strategy-160926.pdf [Accessed 25 October 2019].

Northern Territory Environment Protection Authority (2019) *Guidance for Proponents – Stakeholder Engagement. Version 1.0*, Northern Territory Environment Protection Authority, Darwin. [Online] Available at: https://ntepa.nt.gov.au/__data/assets/pdf_file/0011/700949/guideline_proponents_stakeholder_engagement.pdf [Accessed 25 October 2019].

## 4.7. References included in Appendix

GHD (2019e) *Social and Economic Impact Assessment, Rum Jungle Rehabilitation Project Report,* Report to the Department of Primary Industry and Resources, Northern Territory.

# 5. Regional Setting

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## 5.1. Land Tenure and Land Use

The former Rum Jungle Mine is located approximately 105 km south of Darwin, and 6 km north of Batchelor, NT as shown in Figure 5-1. The tenure of the project components, as previously described, are:

- Rum Jungle proper – Section 2968 Hundred of Goyder (vacant NT Crown land recommended for grant by the Aboriginal Land Commissioner Justice Toohey on 22 May 1981);
- Mt Burton – Section 998 Hundred of Goyder (estate in fee simple held privately);
- Mt Fitch – within NT Portion 3283 (Crown Lease Perpetual 862 held by the Northern Territory Land Corporation);
- Low permeability materials are proposed to be sourced from pre-disturbed land owned by CCGC; and
- Granular materials are proposed to be sourced from lands including and surrounding a former sand mining area which is now located on the FRALT.

The location of all components, with respect to each other and Batchelor, are shown on Figure 5-2.

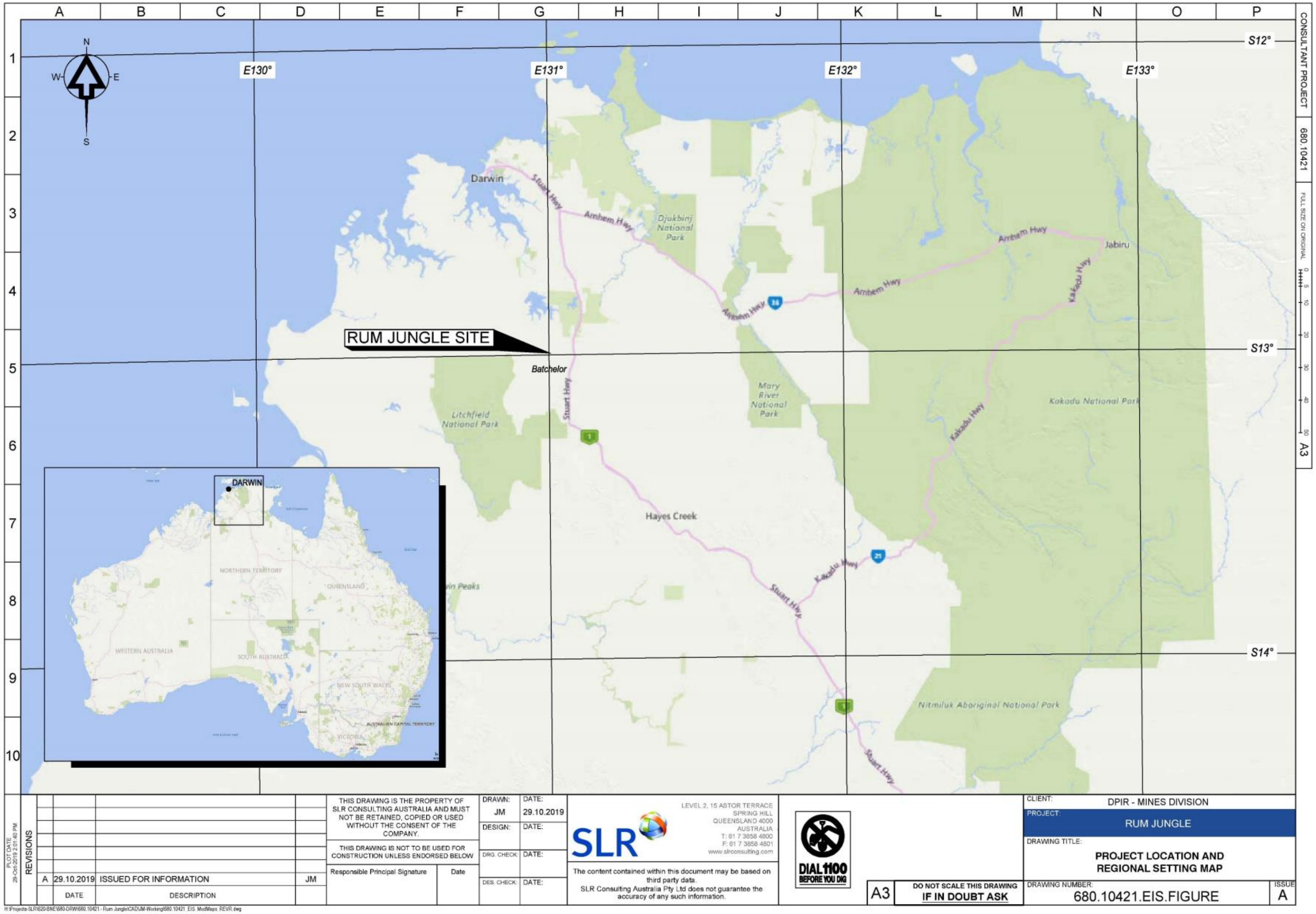



Figure 5-1: Project regional setting

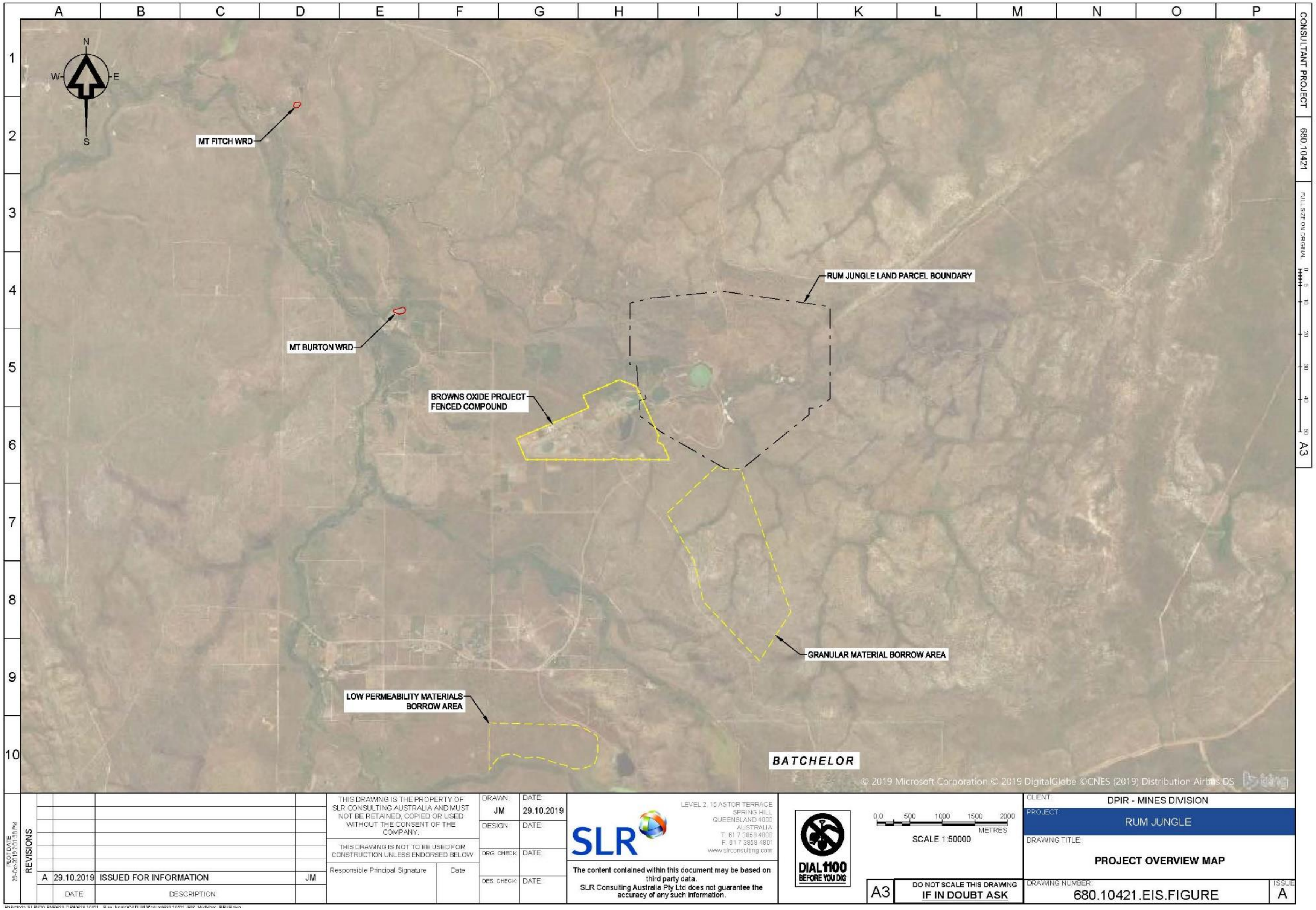



Figure 5-2: Project overview

The project lies within the CCGC local government area which formed in 1990 and includes the towns of Batchelor and Adelaide River, and surrounding rural areas. Approximately 20% of the area forms part of the FRALT and a further 15% is allocated to the protection of the catchment of the Darwin River Dam (CCGC, 2018). At the 2016 census, the area had an estimated population of 1,319 (ABS, 2017) and the average age was 50-54, significantly higher than the rest of the NT (CCGC, 2018).

The *Coomalie Planning Concepts and Land Use Objectives* (DLPE, 2000) establish the legislative framework for planning control within the Coomalie region. The key land use objectives are to protect the region's environmental values whilst promoting development, with an emphasis on the tourism and resources sectors. The *Darwin Regional Land Use Plan 2015* outlines that the Coomalie region continues to contribute to regional growth *via* tourism, education and horticulture and agriculture, and is also of particular importance with respect to mineral and regional water resources (DLPE, 2015).

The principle land uses within the Coomalie region are (DLPE, 2015):

- Open space
- Rural lifestyle
- Grazing or agriculture, and horticulture
- Darwin River and Manton Dams and catchments
- Conservation (Litchfield National Park).

Figure 5-3 highlights the location of the potential Mount Bennett Dam and its catchment on the Finniss River, downstream of the project area. This potential dam was retained in Power and Water Corporation's *Darwin Regional Water Supply Strategy 2013* (2013) as an option for further assessment in the long-term. CSIRO's Northern Australia Water Resource Assessment compared seven potential dam sites in the Darwin catchments, including the Mount Bennett Dam. Whilst the Mount Bennett Dam had the lowest cost to yield ratio, a number of constraints to its potential development were noted including inflow water quality (due to, *e.g.*, Rum Jungle) and cultural matters (Petheram *et al*, 2017).

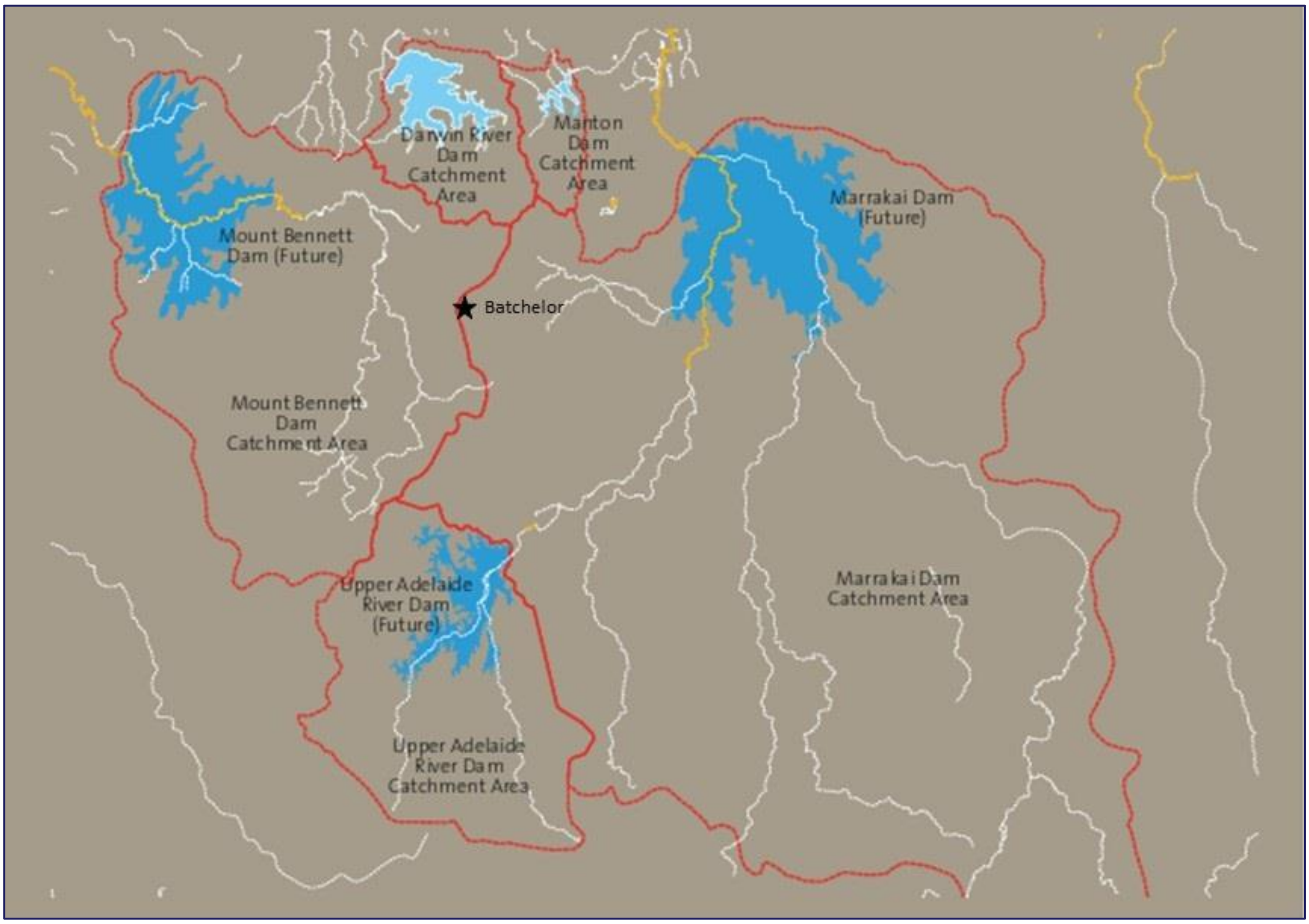



Figure 5-3: Plan of future dam site options for the Darwin region (adapted from PWC, 2013)

## 5.2. Social Setting

The Coomalie region has a diverse mix of cultural aspects. Traditionally, indigenous people lived in the area and the original inhabitants were the Awara, Kungarakan and Warai Peoples. Warai and Kungarakan are recognised as the Traditional Owners of the Rum Jungle site. European settlement commenced around 1870 when the Township of Adelaide River was established to service the Overland Telegraph Line. Since that time, agriculture, mining and defence services formed the foundation for economic and population growth in the area (RDA NT, 2019). It is this history that has given rise to the cultural values addressed within this EIS.

The community of Batchelor[4] has a population of 507 residents, 72.3% were born in Australia and 36.3% identify as Indigenous. The median age of residents in Batchelor is 40 years, compared to a median age of 32 years in the broader NT (ABS, 2017).

The most common type of household structure in Batchelor is couples without children, followed by one parent families. Separate houses remain the predominant dwelling type in Batchelor and the broader Coomalie local government area (ABS, 2017). More specific data on dwelling occupancy, and the community character and demographics is available in the *SEIA Rum Jungle Rehabilitation Project Report* (GHD, 2019e - see Appendix).

<u>Cultural Heritage</u>

Cultural heritage value can be both tangible, as in the physical fabric of places and objects, and intangible, as in the spiritual significance of sacred sites. Across the landscape of the region, the Aboriginal and European history can be seen including sacred sites, aboriginal places and objects, mining heritage objects and places, and WWII historical sites. These sites are afforded differing degrees of protection as outlined in Chapter 8 – Historic and Cultural Heritage.

Cultural significance for Aboriginal people is found in natural features such as landforms, flora and watercourses. There is substantial evidence of Aboriginal occupancy and use of the Coomalie region in the presence of scattered and clustered artefacts (*e.g.* Heritage Surveys, 2002; Begnaze, 2005; Coffey, 2007; Coffey, 2009) and recorded and registered sacred sites (*e.g.* AAPA Authority Certificate C2001/040 awarded to Mt Grace Resources NL (Murgatroyd, 2001; Coffey, 2009)) reflecting Aboriginal occupancy of the land. Notably, Custodians (considered to be from the Kungarakan and Warai) have expressed '*all subsurface water and water courses to be of spiritual significance*' and are concerned with activities that impact these landscape features (Murgatroyd, 2001)

The Proponent recognises that traditional Indigenous knowledge systems value species in an interconnected ecosystem and particular species may have cultural significance in different ways – for example, in a particular location, or to a particular group of people, or for its medicinal, food, ceremonial or other utilitarian purpose.

## 5.3. Existing Services and Infrastructure

The services and infrastructure in the Coomalie region, located in Batchelor (unless otherwise noted), are:

- Emergency Services: Police Station (Batchelor, Adelaide River), Volunteer Fire Brigade and Bushfires NT headquarters.
- Essential Services: Fixed power, potable water supplied by the regional aquifer (the Coomalie Dolostone) (both provided by NT PowerWater Corporation) and domestic waste (Batchelor and Adelaide River Waste Transfer Stations). Fixed power services are located nearby to the Rum Jungle site however the site, itself, is not connected to the grid nor is it serviced by water or sewage.
- Health Services: Community Health Centre (Batchelor, Adelaide River) and Red Cross Home Care. The closest hospitals are Palmerston Regional Hospital or Royal Darwin Hospital.
- Airport: Batchelor Airport (a remnant of WWII activities) is located 9 km from the project. In June 2019, the NTG released a Master Plan for Batchelor Airport, including imminent expansion (DIPL, 2019).
- Community and Recreation: library (Batchelor, Adelaide River), the Coomalie Art Centre and Batchelor Museum as well as a swimming pool, lawn bowls green, football ovals (Batchelor, Adelaide) and Lake Bennett. Recreational activities in the area include fishing, bird watching, bushwalking, swimming, camping, horse riding and four-wheel driving. The Batchelor Outdoor Education Centre is a long-standing, heavily used facility visited by many schools across the Darwin and Katherine regions for school camps and recreational programs, as well as corporate team building activities.
- Education: School (Batchelor: P-12; Adelaide River: P-6) and BIITE.

[4] Figures for Batchelor (State Suburbs) (SSC70024).

- Accommodation: range of accommodation facilities generally catering for the caravanning market with some other specialist accommodation available (CCGC, 2018).

A full description of existing infrastructure and services is available in the *SEIA Rum Jungle Rehabilitation Project Report* (GHD, 2019e - see Appendix).

Transport Network

All deliveries to the project areas will utilise the Stuart Highway. The Stuart Highway (A1) is a national highway connecting Darwin, Alice Springs and Port Augusta in South Australia. It is a sealed, first class single carriageway for most of its length. The maximum posted speed limit is 130 km/h. The highway has four lanes (two lanes in each direction) north of the Arnhem Highway.

Other roads of note are:

- Batchelor Road –is a sealed, 12.5 km single carriageway (with no shoulders on the side for its entire length) connecting the Stuart Highway to Batchelor.
- Crater Lake Road – is a sealed, 4 km single carriageway (with no shoulders on the side for its entire length) connecting the Stuart Highway to Batchelor Road.
- Rum Jungle Road – is a sealed, 6.6 km single carriageway (with no shoulders on the side for its entire length) connecting Batchelor with the intersection of Litchfield Park Road.
- Litchfield Park Road – is a sealed, single carriageway connecting Litchfield Park (and the low permeability material borrow area) with the intersection of Rum Jungle Road.

All roads mentioned above, other than Crater Lake Road, are under the care and control of the NTG; Crater Lake Road is managed by CCGC.

Monthly Average Daily Traffic (ADT) data demonstrates an increase in traffic volume on the Batchelor Road and Litchfield Park Road (passed RJCS intersection) over the Dry season (Table 5-1), dominated by cars (Vehicle Class 1) and, to a lesser extent, by caravans (Vehicle Class 2) and two-axle buses (Vehicle Class 3) (Table 5-2) (TAMS, 2018).

Table 5-1: Calculated Annual ADT and Monthly ADT for Batchelor Primary Stations, 2018 (TAMS, 2018)

| Road Name/ Location | Station No | Direction | Units | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | AADT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Batchelor Road | RDVDP015 | Inbound | Veh | 278 | 284 | 321 | 424 | 445 | 514 | 615 | 526 | 455 | 406 | 341 | 307 | 410 |
| 5 km west of Stuart Highway | | Outbound | Veh | 278 | 281 | 310 | 416 | 426 | 492 | 597 | 511 | 440 | 391 | 328 | 287 | 397 |
| | | Both | Veh | 556 | 565 | 631 | 840 | 871 | 1006 | 1212 | 1037 | 895 | 797 | 669 | 594 | 807 |
| Litchfield Park Road | RDVDP035 | Inbound | Veh | 127 | 95 | 102 | 223 | 219 | 296 | 428 | 306 | 220 | 176 | 96 | 98 | 202 |
| 5 km west of Finniss River Crossing | | Outbound | Veh | 132 | 96 | 106 | 244 | 251 | 341 | 487 | 347 | 250 | 199 | 110 | 112 | 227 |
| | | Both | Veh | 259 | 191 | 208 | 467 | 470 | 637 | 915 | 653 | 470 | 375 | 206 | 210 | 429 |

Adjusted Data

Table 5-2: Vehicle Classification measured at Batchelor Primary Stations, 2018 (TAMS, 2018)

| Road Name/Location | Station | Direction | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Batchelor Road | RDVDP015 | Inbound | 78.41 | 8.86 | 9.30 | 0.80 | 0.26 | 0.89 | 0.87 | 0.05 | 0.20 | 0.23 | 0.09 | 0.04 |
| 5 km west of Stuart Highway | | Outbound | 83.26 | 8.02 | 6.36 | 0.78 | 0.22 | 0.42 | 0.35 | 0.06 | 0.21 | 0.23 | 0.07 | 0.03 |
| | | Both | 80.83 | 8.44 | 7.83 | 0.79 | 0.24 | 0.65 | 0.61 | 0.06 | 0.21 | 0.23 | 0.07 | 0.03 |
| Litchfield Park Road | RDVDP035 | Inbound | 82.96 | 6.42 | 8.69 | 0.85 | 0.05 | 0.50 | 0.34 | 0.02 | 0.03 | 0.01 | 0.11 | 0.02 |
| 5 km west of Finniss River Crossing | | Outbound | 81.65 | 5.51 | 11.15 | 0.47 | 0.05 | 0.66 | 0.36 | 0.01 | 0.03 | 0.01 | 0.09 | 0.00 |
| | | Both | 82.26 | 5.94 | 10.00 | 0.65 | 0.05 | 0.59 | 0.35 | 0.01 | 0.03 | 0.01 | 0.10 | 0.01 |

*Class 1- car/4WD/motorcycle; Class 2 – car/4WD towing; Class 3 – two axle bus/truck; Class 4 – three axle bus/truck; Class 5 – four axle truck; Class 6 – three axle articulated; Class 7 – four axle articulated; Class 8 – five axle articulated; Class 9 – six axle articulated; Class 10 – B Double; Class 11 – double road train; Class 12 – triple road train.*

*Note: Data only reported for July and August 2018.*

# 5.4. Economic Setting

The Coomalie region is underpinned by a narrow base, with vocational education and training, and tourism, respectively, being the region's principal provider of jobs and the main drivers of its economic development (ABS, 2017) (Table 5-3).

Table 5-3: Industries of employment for Batchelor and Coomalie region (ABS, 2017)

| Industry of employment | Batchelor (%) | Coomalie (%) | NT (%) |
|---|---|---|---|
| Technical and vocational education and training | 26.1 | 15.7 | 0.3 |
| Accommodation (*i.e.* tourism) | 9.4 | 10.5 | 2.3 |
| Beef Cattle farming (specialised) | - | 4.4 | 1.0 |
| Local government administration | - | 4.1 | 1.9 |
| Combined primary and secondary education | 9.4 | 3.9 | 1.5 |
| State government administration | 4.3 | - | 6.2 |
| Gold ore mining | 3.6 | - | 0.3 |

The majority of the population in Coomalie region and Batchelor are in the workforce (Table 5-4). It is noted that the median income of Indigenous people in the Coomalie region is considerably greater than the median income across the NT (Table 5-5).

Table 5-4: Employment in Batchelor and Coomalie region (ABS, 2017)

| Employment | Batchelor (%) | Coomalie (%) | NT (%) |
|---|---|---|---|
| Worked full-time | 56.8 | 60.2 | 67.1 |
| Worked part-time | 23.6 | 23.0 | 19.5 |
| Away from work | 5.0 | 6.9 | 6.4 |
| Unemployed | 14.6 | 7.0 | 7.0 |

Table 5-5: Indigenous and non-indigenous income comparison (ABS, 2017)

| Median total personal income $/week | Coomalie | NT ($) |
|---|---|---|
| Indigenous persons/households with Indigenous persons | $450 | $281 |
| Non-indigenous persons/households | $654 | $1,072 |

# 5.5. Physical Environment

## 5.5.1. Climate

The climate of the Top End, including the Coomalie region, is classified as 'tropical savanna' under the Köppen climate classification system and is characterised by a distinctly seasonal dry-wet monsoon cycle (BoM, 2016). The Wet season generally extends from October to April and experiences predominantly westerly to north-westerly winds, while the Dry season (May-early October) experiences minimal (or lower) rainfall and experiences predominantly easterly to south-easterly winds (Table 5-6).

Table 5-6: Average annual temperature, rainfall, humidity and wind speed, Darwin-Daly rainfall district

| Location | Temperature (°C) | | Rainfall (mm) | | Relative Humidity (%) | | Wind speed (km/h) | |
|---|---|---|---|---|---|---|---|---|
| | Minimum | Maximum | Rainfall | Number of days of rain ≥ 1 mm | 9am | 3pm | 9am | 3pm |
| **Batchelor Airport** | 21.2 | 33.7 | 1564.4 | 85.8 | 72 | 45 | 9.0 | 11.6 |
| **Tindal RAAF** | 20.5 | 34.0 | 1088.8 | 60.7 | 63 | 36 | 10.1 | 12.8 |
| **Darwin Airport** | 23.2 | 32.1 | 1731.2 | 94 | 71 | 54 | 10.9 | 17.9 |

*Batchelor Airport Station (014272); Tindal RAAF Station (014932), which is approximately 213.5 km south of Batchelor; Darwin Airport Station (014105), 75.6 km north of Batchelor. Taken from BoM (2019a-c) using all available data.*

The average annual rainfall is approximately 1,564 mm at Batchelor Airport (1994-2019), about 90% of which falls over the five months between November and March. The hottest month is October, with a mean maximum temperature of 36.8°C, and the coolest month is July, with a mean minimum temperature of 16.4°C (1992-2019) (BoM, 2019a). During the Wet season, humidity generally exceeds 65%, while the Dry season has lower humidity, generally less than 60% (BoM, 2019a; World Weather Online, 2019). Detailed information about the monthly climate experienced at Batchelor, and what the project area can be anticipated to experience, is at Table 5-7.

Table 5-7: Monthly climate averages, Batchelor Airport (BoM, 2019a)

| Month | Temperature (°C) | | Rainfall (mm) | Relative Humidity (%) | | Wind Speed (km/h) and Direction* | |
|---|---|---|---|---|---|---|---|
| | Maximum | Minimum | | 9am | 3pm | 9am | 3pm |
| January | 32.7 | 24.0 | 331.7 | 87 | 70 | 8.6 / W | 11.5 / W-NW |
| February | 32.5 | 23.8 | 320.6 | 90 | 70 | 7.6 / W | 11.0 / W-NW |
| March | 33.1 | 23.5 | 235.8 | 86 | 61 | 7.4 / E | 11.0 / E |
| April | 33.8 | 21.8 | 86.8 | 74 | 45 | 9.0 / E-SE | 13.1 / E-SE |
| May | 32.8 | 19.1 | 27.3 | 61 | 35 | 11.7 / E-SE | 13.4 / E-SE |
| June | 31.6 | 17.0 | 0.4 | 53 | 30 | 14.4 / SE | 14.2 / E-SE |
| July | 32.0 | 16.4 | 0.8 | 55 | 26 | 10.7 / E-SE | 12.7 / E-SE |
| August | 33.4 | 17.0 | 2.0 | 60 | 25 | 9.7 / E-SE | 12.4 / E-SE |
| September | 36.0 | 20.5 | 7.8 | 68 | 28 | 7.4 / N-E | 11.1 / E-SE |
| October | 36.9 | 23.0 | 63.2 | 70 | 35 | 7.0 / N | 10.1 / N-E |
| November | 35.6 | 24.0 | 137.5 | 75 | 48 | 6.4 / W-N-E | 9.0 / W-N-E |
| December | 33.9 | 24.2 | 267.5 | 82 | 63 | 7.7 / W | 10.2 / W-NW |

** N=North; E=East; S=South; W=West*

Daily evaporation measurements have been made at Batchelor Airport since 2010 using a Class A pan evaporator. The average monthly pan evaporation ranges from 240 mm in October to a low of 160 mm in February (DES, 2019). The average rainfall and evaporation values for Batchelor Airport are at Figure 5-4; annual pan evaporation exceeds rainfall by approximately 770 mm (2010-2019).

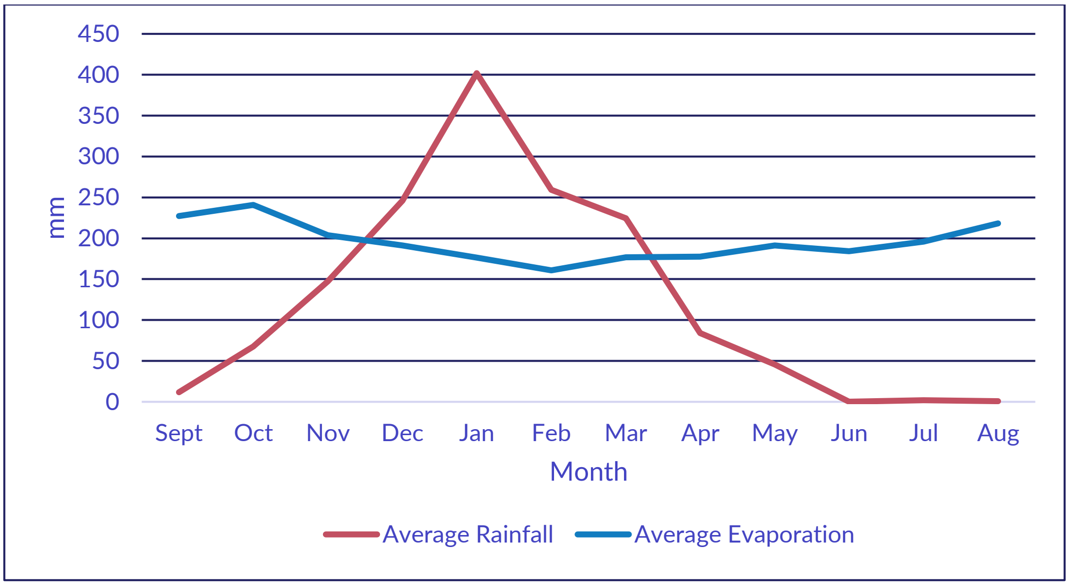



Figure 5-4: Monthly rainfall/evaporation for Batchelor Airport (2010-2019)

## 5.5.2. Extreme Climate Events

Northern Australia experiences seasonal extreme weather events such as storms, intense rainfall and strong winds; and these weather events are likely in the Coomalie region.

The Australian tropical cyclone season occurs between November and April. Increased tropical cyclone activity has been associated with La Niña years, while below normal activity has occurred during El Niño years (CSIRO and BoM, 2015). The long-term average number of tropical cyclones in Australia is 11, of which three occur in Northern Australia (including the Gulf of Carpentaria) (BoM, 2019d). In the NT, tropical cyclones generally affect coastal areas up to 50 km inland (NTG, 2019b).

## 5.5.3. Climate Change

Climate models predict (CSIRO, 2014, 2016):

- average temperatures will continue to increase in all seasons with increased evapotranspiration;
- despite natural variability remaining the major driver of rainfall changes over the next few decades, there will be an increase in the intensity of extreme rainfall events and increased flooding risk;
- fire frequency will remain unchanged but when fires do occur, their behaviour will be more extreme;
- rising sea levels; and
- fewer but more intense tropical cyclones.

## 5.5.4. Geology

The Coomalie region is located in the north-western section of the Pine Creek Orogen which covers an area of about 47,500 km$^2$ and extends north from Katherine to near Darwin (McCready *et al.*, 2004; Ahmad *et al.*, 2006; Ahmad and Hollis, 2013) (Figure 5-5). It is comprised of sequences of carbonaceous, clastic and volcanogenic sediments deposited over two Archaean granitic basements.

The area around Rum Jungle features two dome-like Archaean basement highs – the Rum Jungle and Waterhouse Complexes. Both Complexes are primarily granitic overlain with meta-sedimentary and subordinate meta-volcanic rocks called the Mount Partridge Group.

The Mount Partridge Group consists of repetitive clastic-carbonate sequences of the Namoona Group. From oldest to youngest, the three major formations of the Mount Partridge Group are:

- Crater Formation – coarse and medium-grained siliciclastics (*e.g.* sandstone)
- Coomalie Dolostone – magnesite and dolomite with minor chert lenses
- Whites Formation – graphitic, sericitic, chloritic and calcareous slate-phyllite-schist.

The Mount Partridge Group has been folded, faulted and metamorphosed to greenschist facies, but the original stratigraphic succession has been preserved. Faults have occurred, some of which follow the northeast-southwest structural trend in the area. Protorezoic-age Geolsec Formation lies unconformably over the Mount Partridge Group and consists of hematite quartzite breccia.

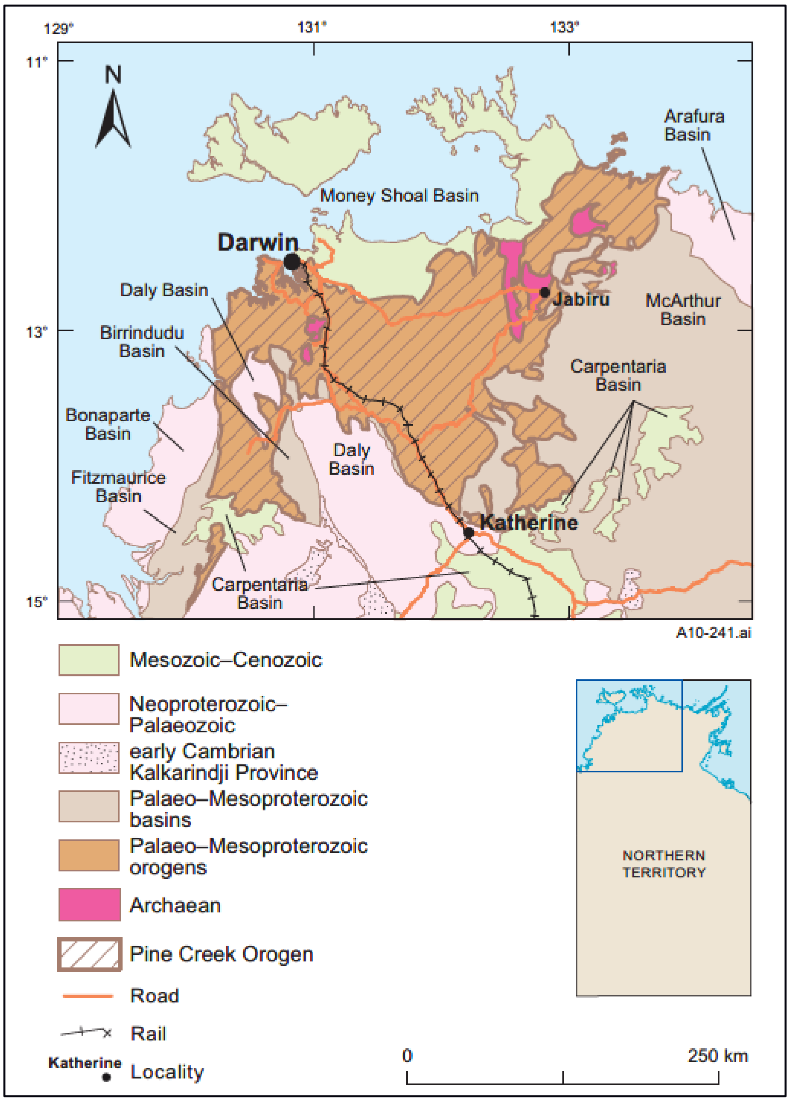



Figure 5-5: Geological setting of the Pine Creek Orogen: inset is location within NT (Ahmad and Hollis, 2013)

Rum Jungle sites within a triangular area known as 'The Embayment' (Ahmad *et al.*, 2006; Ahmad and Hollis, 2013). The area lies in a shallow-dipping limb of a northeast trending, southwest plunging asymmetric syncline that has been cut by northerly trending faults. The main lithologic units of The Embayment are granites of the Rum Jungle Complex (south-eastern side of the Giants Reef Fault) and meta-sedimentary rocks of the Mount Partridge Group (north of the Giants Reef Fault) (Figure 5-6).

Each of the polymetallic ore deposits within The Embayment occurs within the Whites Formation near its contact with Coomalie Dolostone. Deposits are strongly associated with fault zones (and hence structurally controlled).

Near surface, *in situ* laterisation has occurred since the early Mesozoic era and Tertiary period and, as such, deeply weathered soil profiles are present. Laterite tends to occur above the Coomalie Dolostone, whereas saprolite is more common in areas where the predominant bedrock is Geolsec Formation or Rum Jungle Complex. Alluvium occurs near Fitch Creek and the upper EBFR. Unconsolidated sediments also occur in the diversion channel, but they are relatively thin and discontinuous.

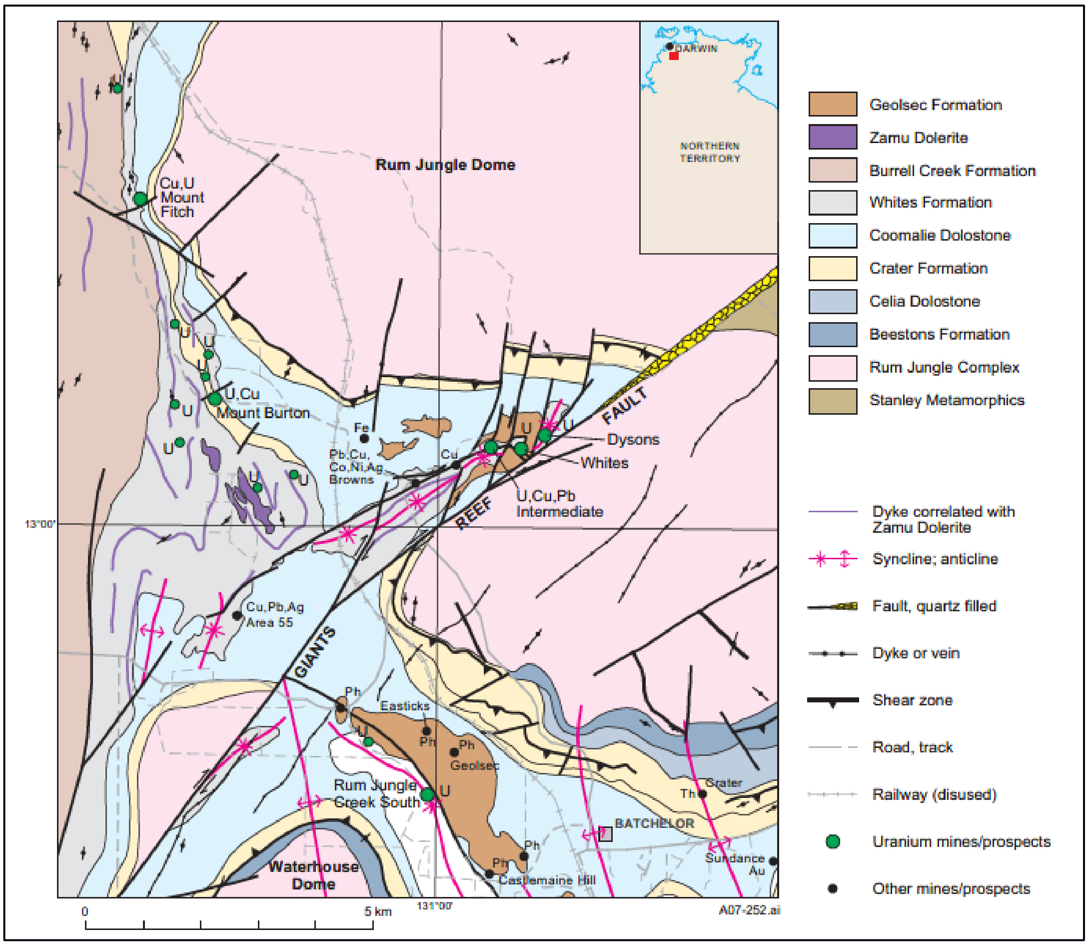



Figure 5-6: Geology of the Rum Jungle Mineral Field showing U and other mineral occurrences (Ahmad and Hollis, 2013)

## 5.5.5. Soil Types and Land Units

Coomalie region's soils are classified as:

- Kandosols – red, yellow and brown earths.
- Tenosols – weakly developed or sandy soils that show some degree of development (minor colour or soil texture increase in subsoil) down the profile.
- Hydrosols – seasonally inundated soils.

## 5.5.6. Water

<u>Hydrology</u>

The project area sits within the headwaters of the Finniss River catchment; the majority of the project footprint is within the EBFR sub-catchment, the exceptions being Mt Burton and Mt Fitch which are adjacent to the West Branch of the Finniss River, and the low permeability borrow area which is adjacent to Meneling Creek (which flows into the West Branch) (Figure 5-7).

The EBFR is an ephemeral stream which drains north-west, joining the Finniss River approximately 8 km downstream of the Rum Jungle site. Base flow is generally not established until sustained monsoonal rains arrive. Salts deposited during recessional flow of the previous year are remobilised during the first flow events.

The Finniss River is a perennial river that flows to Fog Bay. During the Wet season the river often overbanks whilst during the Dry season the river typically consists of a series of billabongs about 3 m in depth connected by shallower sections.

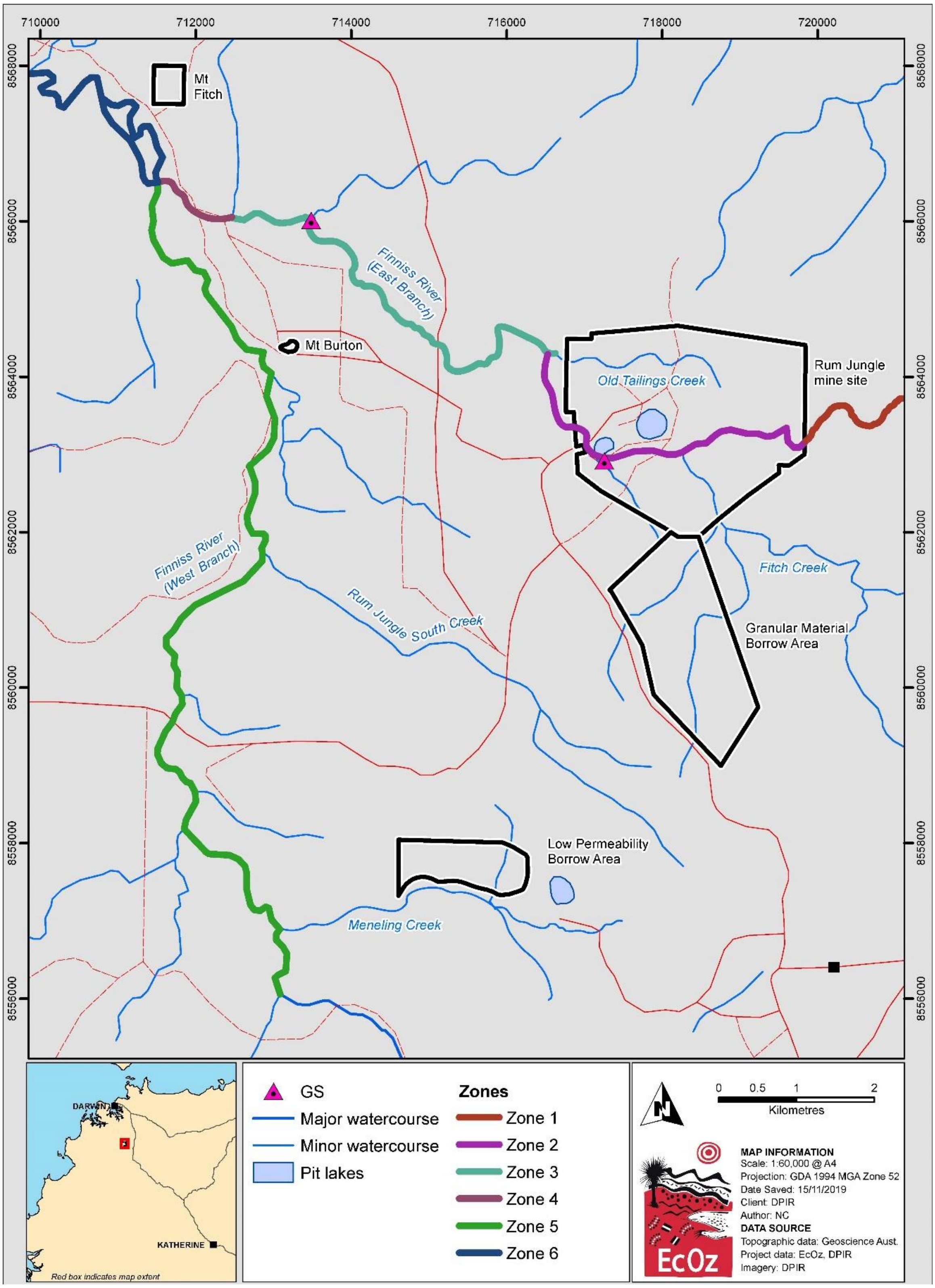



Figure 5-7: Surface water features

Water Quality

The surface water quality onsite and within the impact footprint has been well monitored over time to establish the extent of surface water impacts resulting from AMD. As described in Chapter 1 - Introduction, earlier rehabilitation works gave rise to a substantial improvement in water quality onsite and downstream, however the system remains impacted from ongoing AMD generation. A downstream impact assessment (Hydrobiology 2016) found the impact on aquatic ecosystems within the Finniss River were that:

- for several metals, Water Quality Objectives (WQOs) are exceeded on a regular basis;
- the Wet season first flush pulses of elevated metals above WQOs have been observed downstream for several elements (copper, cobalt, manganese, nickel and zinc); and
- metals typically evapo-concentrate on site though downstream the Dry season metal concentrations reduce.

This impact assessment divided the downstream Finniss River receiving environment into nine zones to enable the setting WQOs (Hydrobiology, 2013). The zones took into account: known historic and current patterns of effects on water and sediment quality; the separation of fresh and estuarine waters; and the position of the Site of Conservation Significance (SoCS) - Finniss River coastal floodplain (Harrison *et al.*, 2009a). Zones 1 to 7 are: (Figure 5-8):

1. East Branch and tributaries upstream of the Rum Jungle Mine.
2. East Branch within the mine site area to the junction with Old Tailings Creek.
3. East Branch from Old Tailings Creek to Hannah's Spring.
4. East Branch from Hannah's Spring to the junction with Old Tailings Creek.
5. Finniss River upstream of the East Branch.
6. Finniss River from the East Branch to Florence Creek.
7. Finniss River from Florence Creek to the upstream boundary of the SoCS.

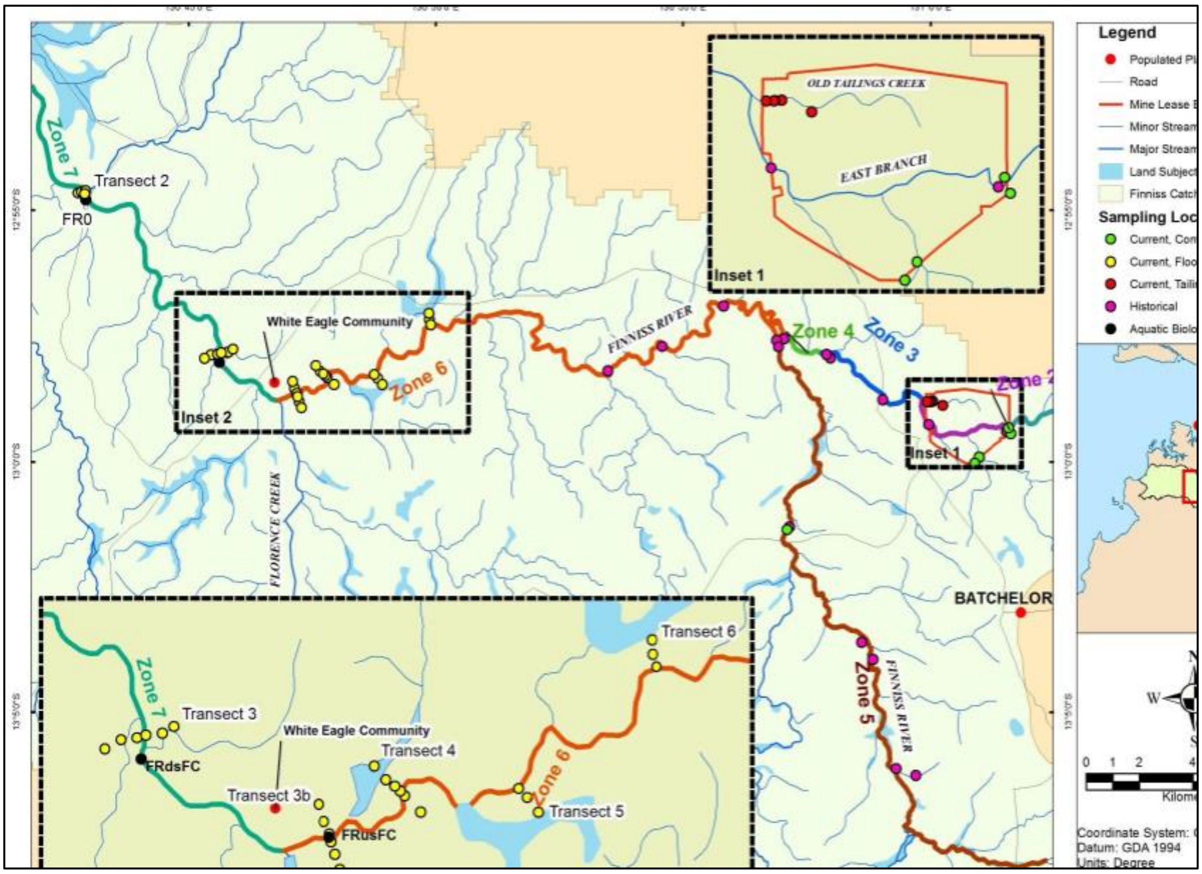



Figure 5-8: Finniss River zones as developed by Hydrobiology (2019)

The concentration profiles of the main Contaminant of Concern (copper) along the Finniss River system is shown in Figure 5-9 which has been extracted from the Hydrobiology (2016) report – it shows that copper concentration is elevated in Zone 2 (mine area) and then declines downstream.

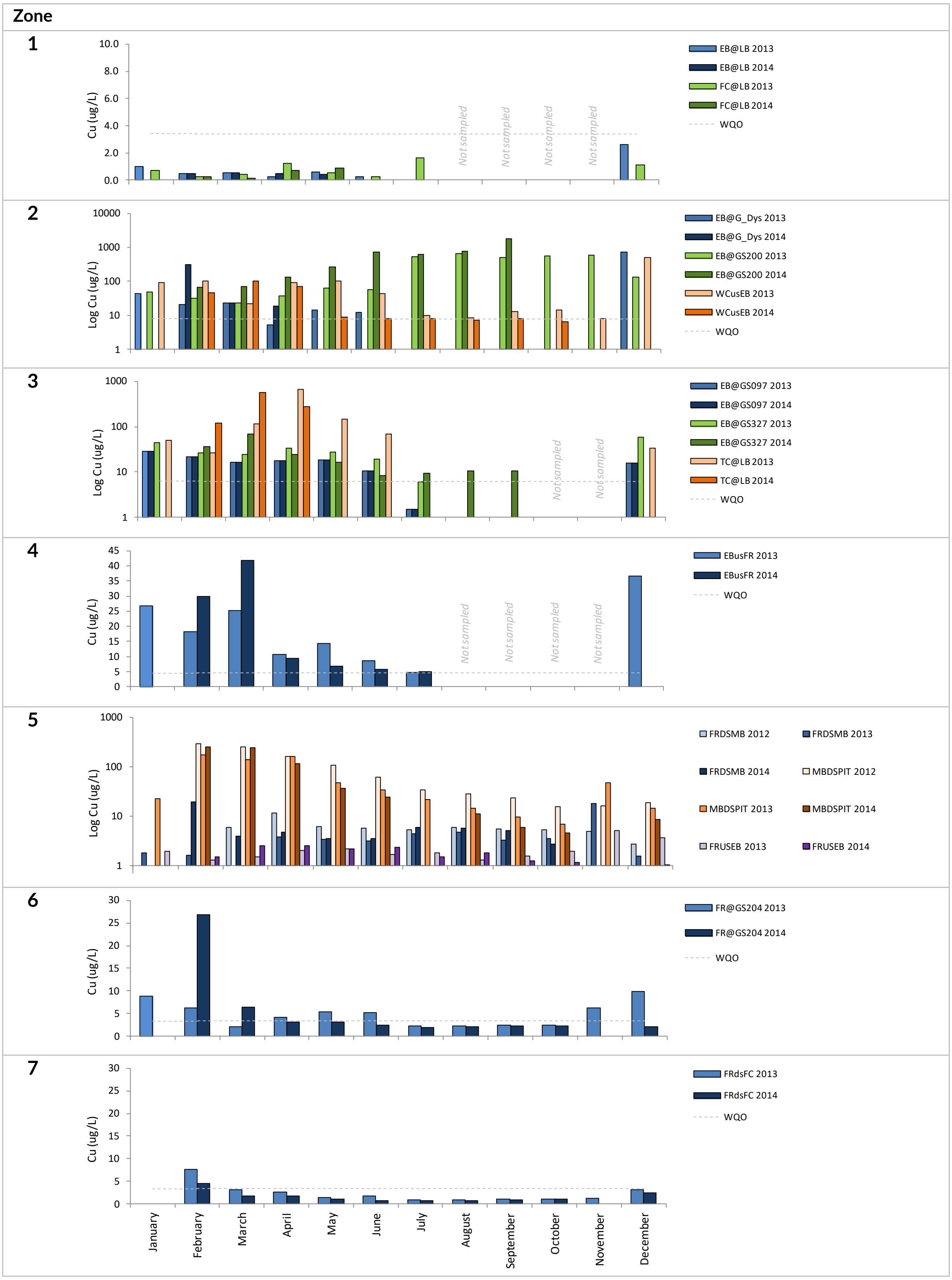



Figure 5-9: Dissolved copper concentrations by site, zone and months, Jan - Dec 2012 - 2014 (Note Y axis differences) (Hydrobiology, 2016)

The impact of this water quality to aquatic ecosystems is described in Chapter 12 – Aquatic Ecosystems. A detailed discussion on the water quality impacts in Zones 2 and 3 is located in Chapter 10 – Inland Water Environmental Quality of this EIS.

Users

There nearest recorded Surface Water Extraction Licence to the project area is 817177 on Coomalie Creek, about 10 km east. There are three Groundwater Extraction Licences in proximity to the project area – RN008822, RN020720 and RN020722 are all located in Batchelor; the latter two bores are current Power and Water production bores. The project components closest to these Licences are the low permeability material borrow (about 3 km) and the granular material borrow/Rum Jungle site (about 5 km).

Design Rainfall Depth

There are several regional weather stations including Adelaide River Post Office and Batchelor Airport. The Bureau of Meteorology provides the 2016 Design Rainfall Data System including the Intensity-Frequency-Duration (IFD) Design Rainfall Depth as shown in Figure 5-10.

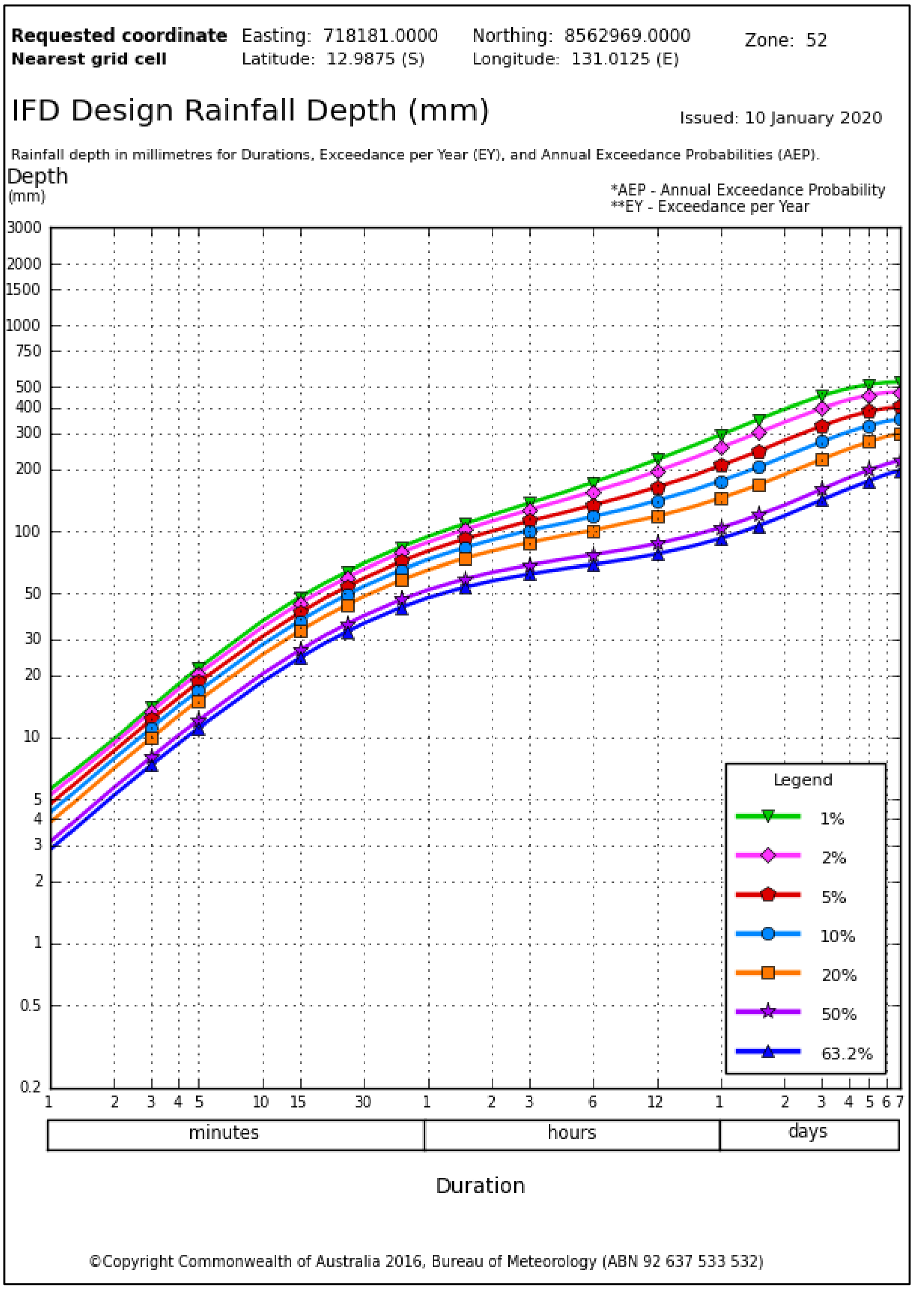



Figure 5-10: IFD Design Rainfall Depth (Bureau of Meteorology, 2019e)

# 5.6. Biological Environment

## 5.6.1. Bioregions

Bioregions for the Australian continent have been created as part of a national classification of ecosystems, termed the Interim Biogeographic Regionalisation of Australia, to support conservation initiatives (Thackway and Cresswell, 1995). There are currently 89 bioregions and 419 sub-regions in Australia, and each is based on similarities in climate, geology, landform, native vegetation and species information (DoEE, 2018).

The Coomalie region is located in the western section of the 28,500 km$^2$ Pine Creek Bioregion (Figure 5-11). The features of the Pine Creek Bioregion are (Bastin and ACRIS Management Committee, 2008):

- Landscape is mainly hilly to rugged ridges with undulating plains
- Eucalypt woodlands with patches of monsoon forests
- Major land uses are conservation, pastoralism, intensive rural freehold blocks, horticulture and mining
- Major population centres are Batchelor, Adelaide River, Pine Creek and Jabiru.

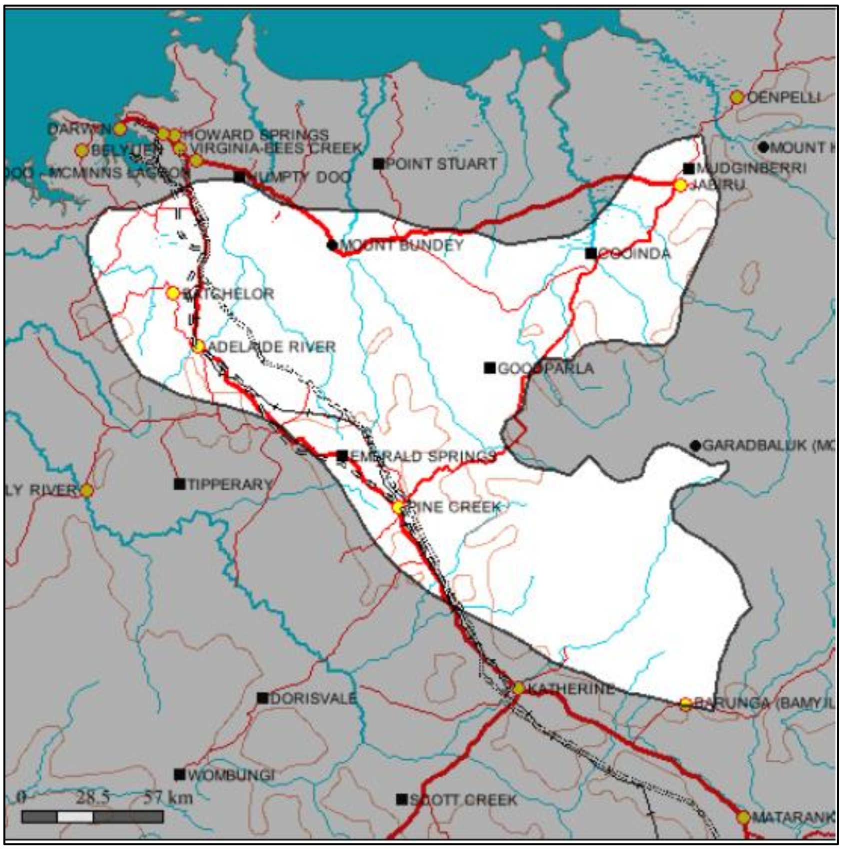



Figure 5-11: Location of Pine Creek Bioregion (Charles Darwin University (2011) – NRM InfoNet)

## 5.6.2. National Parks and Protected Areas

The project area is surrounded by, or within 20 km of, the following national parks or protected areas including:

- Declaration of Beneficial Uses Fog Bay Area contains the Finniss River catchment (including the entire project area). The following beneficial uses have been declared for the area – aquatic ecosystem protection and recreation water quality and aesthetics (DLPE, 1999a).
- Litchfield National Park (8 km south-west of the Rum Jungle site) is owned and managed by the Parks and Wildlife Service of the NT and is characterised by the presence of sandstone plateaus, monsoon rainforests and swamps, *Melaleuca* woodlands and lowlands, and alluvial plains.

- Darwin Dam Catchment (less than 2 km north of the Rum Jungle site) provides raw water to the Darwin River Dam and the following beneficial uses have been declared over the Darwin and Blackmore Rivers (all tributaries) – aquatic ecosystem protection, recreational water quality and aesthetics, and agricultural water use (DLPE, 1999b).
- Additionally, the northern portion of the project area falls within the Darwin Rural Water Control District, declared for surface water and groundwater management purposes (DENR, 2019). The area's hydrogeology is complex with 13 significant aquifers including the Coomalie Dolostone formation.
- Manton Dam Recreation Area provides an emergency water supply to Darwin and is a valuable catchment and conservation area (Parks and Wildlife Commission, 2017a).

The Finniss River drains in to two SoCS – the Finniss River coastal floodplain (Harrison *et al.*, 2009a) and the contiguous Fog Bay (Harrison *et al.*, 2009b). The Finniss River coastal floodplain is dominated by seasonally inundated grassland and sedgeland with areas of paperbark open forest. Both SoCS are considered to have international significance due to the large aggregation of waterbird species, including Magpie Geese and Pied Herons, and national significance due to the presence of threatened species and wetlands.

There are no Sites of Botanical Significance in the Coomalie region or downstream (towards Fog Bay).

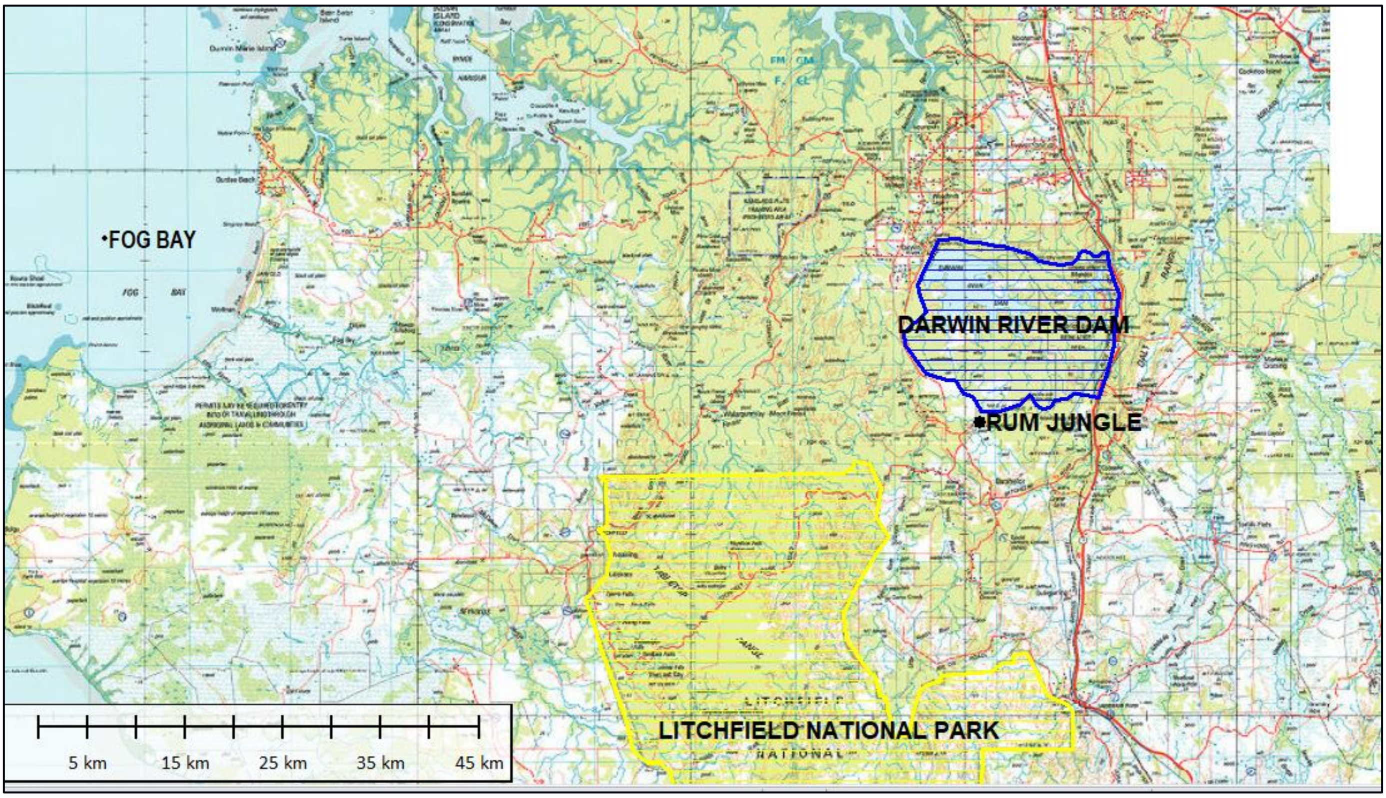



Figure 5-12: Project in relation to Litchfield National Park, Fog Bay and Darwin River Dam Catchment (NT Topographic Map 1:250,000)

## 5.6.3. Flora and Fauna

Vegetation Communities

Metcalfe (2002) surveyed a 37.5 $km^2$ area, identifying and describing 10 main vegetation communities. The dominant vegetation comprises mainly *Eucalyptus*-dominated woodland and open woodland communities (59% of survey area). This vegetation community – also known as savanna – is common, widespread and characteristic of the region generally. The remaining vegetation is predominantly riparian habitats, *Lophostemon* communities associated with low-lying drainage areas, and Ghost Gum (*Corymbia bella*) open woodlands and Paperbark (*Melaleuca* spp.) communities on surrounding floodplains.

A summary of the habitat types within the Coomalie region, as classified by Metcalfe (2002), can found in Figure 5-13 and Table 5-8.

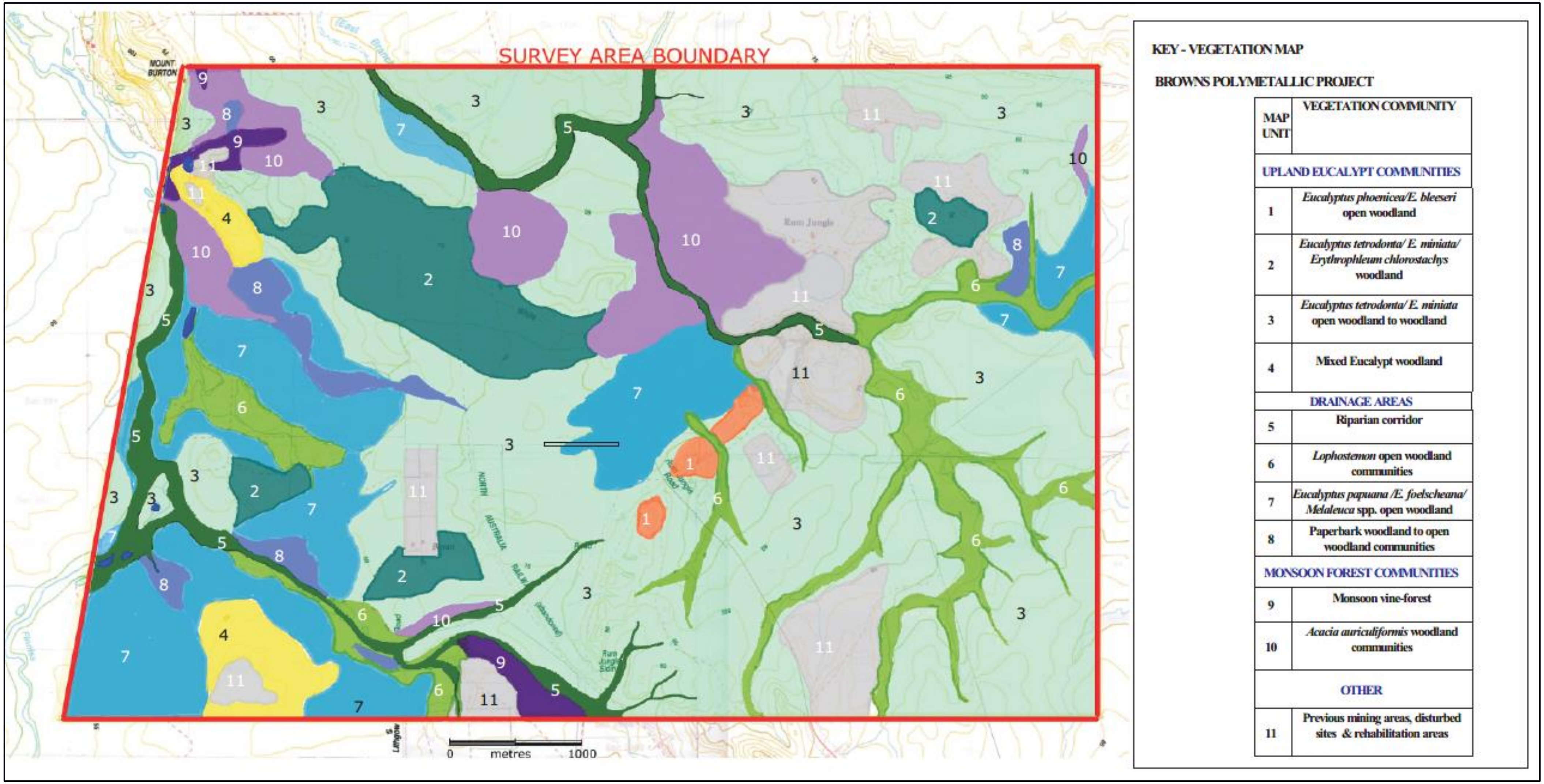



Figure 5-13: Vegetation communities in the Coomalie region (Metcalfe, 2002)

Table 5-8: Summary of vegetation types in the Coomalie region (adapted from Metcalfe, 2002)

| Habitat | Summary description |
|---|---|
| 1 | *Eucalyptus phoenicea*/*Corymbia bleeseri* Open Woodland<br>The dominant species *E. phoenicea* forms an open woodland to 8 m above a sparse mid- and ground stratum layer. Common upper stratum species include *C. bleeseri* and *Eucalyptus miniata* (Darwin WoolyButt); *Erythrophleum chlorostachys* (Ironwood) and *Eucalyptus tetrodonta* (Darwin Stringybark) may occur. Common mid-stratum species, to 4 m, include *Xanthostemon paradoxus*, *Owenia vernicosa*, *Livistona humilis*, *Acacia* spp. and *Terminialia ferdinandiana*. Ground cover typically comprises dense annual grasses (*Heteropogon contortus*, *Themeda triandra*, *Sorghum* spp.), juvenile Eucalypts, herbs and a variety of sub-shrubs including *Petalostigma quadriloculare* and *Grevillea dryandrii*. |
| 2 | *E. tetrodonta*/*E. miniata*/*E. chlorostachys* Tall Open Forest to Woodland<br>Tall open forest to woodland (15 m) dominated by *E. tetrodonta*, *E. miniata* and *E. chlorostachys*; other common species occurring include *Syzygium suborbiculare* (Red Bush Apple) and *Alstonia actinophylla* (Milkwood). The understorey layer is typically mid-dense with low trees to 6 m; the most common species include *Pandanus spiralis*, *Persoonia falcate* and *Livistona humilus*. Ground cover is typically a mid-dense to sparse grassy layer (including *T. triandra*, *Sorghum* spp.) with a variety of herbs and sub-shrubs. |
| 3 | *E. tetrodonta*/*E. miniata* Open Woodland<br>Tall open (sparse) woodland (12-20 m) dominated by *E. miniata* with *E. tetrodonta* either singly or in co-dominant stands, and there are other species of Eucalypts present in the canopy. The mid-stratum layer typically comprises mixed species, 2-6 m high, including *Acacia* spp., *Cycas armstrongii*, *Brachychiton megaphyllus* and *L. humilis*. *Calytrix exstipulata* (Turkey Bush), *Petalostigma pubescens* (Quinine Bush) and *Gardenia megasperma* (Native Gardenia) may be locally common. Ground cover is dense and comprises mostly seasonal and annual grasses, sub-shrubs, low herbs and vines including *Ampelocissus* spp. |
| 4 | Mixed Eucalypt Woodland<br>Sparse upper canopy (10 m) comprising a mixture of Eucalypts and other tree species. Common secondary trees include *Syzygium bleeseri*, *X. paradoxus*, *Melaleuca viridiflora* and *C. bleeseri*. The shrub layer (2-6 m) is typically mid-dense to dense; common species include *P. pubescens*, *C. armstrongii*, *P. spiralis*, *L. humilis*, *T. ferdinandiana* and *Grevillea decurrens*. Ground covers consists of herbs and sub-shrubs such as *Hibbertia* spp., *Flemingia lineata*, *Grevillea dryandrii* and *Pachynema complanatum*. |
| 5 | Riparian corridor; Woodland to Open Woodland<br>River fringing trees include *Acacia auriculiformis*, *Melaleuca cajuputi*, *Barringtonia acutangula*, *P. spiralis* and occasional *Leptospermum longifolium* (Weeping Tea Tree). |
| 6 | *Lophostemon* communities; Open Woodland to Grassland<br>The small drainage lines and tributary creeks, support a narrow, but dense, woodland community dominated by *Lophostemon lactifluus* with *Lophostemon grandiflorus* forming monospecific stands in localised areas. Other species present may include Paperbarks and *P. spiralis*. The mid-stratum layer is typically sparse; where present, it is characterised by *P. spiralis*, *M. viridiflora* and *Planchonia careya*. Ground cover consists of dense grasses (including *T. triandra*, *Eriachne burkittii*), sedges (including *Fuirena ciliaris*, *Fimbristylis pauciflora*) and floodplain herbs (including *Ludwigia octovalvis*, *Nelsonia campestris*). |
| 7 | *Eucalyptus papuana*/*Corymbia foelscheana*/*Melaleuca* spp.; Open Woodland to Grassland<br>*E. papuana* (Ghost Gum) typically occur as scattered trees above a dense grassland where *Ischaemum australe* is common; other tree species, such as *C. foelscheana* and *Melaleuca* spp., occur in response to localised variation in topography and drainage. |
| 8 | Paperbark communities; Woodland to Open Woodland<br>This habitat typically comprises *Melaleuca* spp. (2-8 m), particularly *M. viridiflora*, *Melaleuca nervosa*, *Melaleuca dealbata* or *Melaleuca leucadendra*. Occasional *L. grandifloras*, *P. spiralis* and *Acacia* spp. may occur. The ground cover is typically a dense grassland comprising *T. triandra*, *I. australe* and *E. burkitti*. |
| 9 | Monsoon Vine Forest; Closed Forest to Open Forest<br>This habitat typically forms a closed canopy forest up to 20 m high. Common canopy species include *Sterculia holtzei*, *Myristica insipida*, *Calophyllum sil*, *Terminalia microcarpa*, *Syzygium minutuliforum*, *Carpentaria acuminate* (a palm), *Microsorum grossum* (a fern) and *Ficus racemose*. Lower layers comprise juvenile canopy trees and vines/scramblers (including *Flagellaria indica*, *Adenia heterophylla*). |
| 10 | *Acacia auriculiformis* communities; Woodland to Open Forest<br>Upper stratum species include *A. auriculiformis*, *E. chlorostachys* and *T. microcarpa*. The ground layer generally consists of vines (including *Tinospora smilacina*, *Parsonsia velutina*) and sapling of upper stratum species. |

In 1977, a survey of land in and around Mt Burton identified *Cycas media* (Zamia Palm) across the survey area in addition to various Eucalypt woodland types and grasslands, dominated by *Panisum* sp. and *Eriachne* sp. (Wood, 1977).

<u>Native Terrestrial Flora</u>

In the past two decades, the project footprint and surrounds have been subject to standard biodiversity surveys in anticipation of this project, as well as for the Mt Grace Magnesium and Browns Oxide projects, the more recent Yarram Iron Ore project and a natural resource strategy for the Coomalie region.

Approximately 370 terrestrial flora species have been recorded in the Coomalie region, including two threatened species (as at February 2019) (Table 5-9). This contrasts to the 974 native plant species recorded on the adjacent Litchfield National Park, including *Cycas armstrongii* (Parks and Wildlife Commission, 2017b).

Table 5-9: Threatened terrestrial flora recorded in the Coomalie region

| Name | Status | | Occurs in project area |
|---|---|---|---|
| | Cth | NT | |
| *Cycas armstrongii* | - | Vulnerable | Yes |
| *Helicteres macrothrix*[5] | Endangered | Endangered | Not recorded[6] |

Further information can be found in Chapter 14 – Terrestrial Flora and Fauna.

Ecological Community

No threatened ecological community, declared under the EPBC Act, is present within the Coomalie region.

Weeds

In the past two decades, the Coomalie region has been surveyed at various times for weeds – about 47 weeds species have been known to occur, a number of which are declared weeds under the *Weeds Management Act 2001* (NT). At least four Weeds of National Significance (WoNS) have been identified – Gamba Grass (*Andropogon gayanus*), Mimosa (*Mimosa pigra*), Olive Hymenachne (*Hymenachne amplexicaulis*) and Bellyache Bush (*Jatropha gossypiifolia*) – all, except for Bellyache Bush, are also found on the project area. Other species of concern are Mission Grass (annual) (*Cenchrus pedicellatum*) and Para Grass (*Urochloa mutica*) – also found on the project area. The 'invasion' of northern Australia by Gamba Grass, Para Grass, Olive Hymenachne, Mission Grass and Mission Grass (annual) is listed under the EBPC Act as a key threatening process to the environment.

A list of priority and opportunistic weed species, as set out in the *Darwin Regional Weed Management Plan 2015-2020* (WMB, 2015) for prioritised management, recorded in the Coomalie region is shown in Table 5-10.

Table 5-10: Priority and opportunistic weed species in the Coomalie region

| Common name | Species | NT Class | WoNS |
|---|---|---|---|
| **Priority weed species** | | | |
| Gamba Grass | *Andropogon gayanus* | B* | Yes |
| Bellyache Bush | *Jatropha gossypiifolia* | B | Yes |
| Mimosa | *Mimosa pigra* | B | Yes |
| Olive Hymenachne | *Hymenachne amplexicaulis* | B | Yes |
| Mission Grass | *Cenchrus* spp. | B | No |
| Grader Grass | *Themeda quadrivalvis* | B | No |
| **Opportunistic coloniser weed species** | | | |
| Hyptis | *Hyptis suaveolens* | B | No |
| Sicklepod | *Senna* spp. | B | No |
| Spinyhead Sida | *Sida* spp. | B | No |
| Snake Weed | *Stachytarpheta* spp. | B | No |

** Class B – growth and spread to be controlled*

Native Fauna

In the past two decades, the project footprint and surrounds have been subject to standard biodiversity surveys in anticipation of this project, as well as for the Mt Grace Magnesium and Browns Oxide projects, the more recent Yarram Iron Ore project and a natural resource strategy for the Coomalie region.

Between 2002 and 2005, approximately 193 native fauna species were recorded in the Coomalie region – 120 birds, 17 amphibians, 32 reptiles and 24 mammals; species richness has subsequently declined following arrival of the poisonous Cane Toad and weeds proliferation. Over the past 20 years, 10 threatened (Table 5-11) and five migratory (Table 5-12) species, classified as at 2019, have been recorded. This contrasts to the 338 native vertebrate species recorded on the adjacent Litchfield National Park – 192 birds, 24 amphibians, 76 reptiles and 46 mammals – and of these, 13 are threatened species (Parks and Wildlife Commission, 2017b).

[5] Formerly was *Helicteres* sp. Glenluckie Creek.
[6] Absence from project area shown on Distribution advice (DLRM, 2016).

Table 5-11: Threatened fauna recorded in the Coomalie region

| Type | Common name | Scientific name | Status | | Last recorded |
|---|---|---|---|---|---|
| | | | Cth | NT | |
| Reptile | Merten’s Water Monitor | *Varanus mertensi* | - | Vulnerable | 2015 |
| Reptile | Mitchell’s Water Monitor | *Varanus mitchelii* | - | Vulnerable | 2015 |
| Reptile | Floodplain Monitor | *Varanus panoptes* | - | Vulnerable | 2002 |
| Bird | Red Goshawk | *Erythrotriorchis radiatus* | Vulnerable | Vulnerable | 2005 |
| Bird | Partridge Pigeon | *Geophaps smithii* | Vulnerable | Vulnerable | 2016 |
| Mammal | Fawn Antechinus | *Antechinus bellus* | Vulnerable | Endangered | 2005 |
| Mammal | Northern Quoll | *Dasyurus hallucatus* | Endangered | Critically Endangered | 2005 |
| Mammal | Northern Brush-tailed Phascogale | *Phascogale pirata* | Vulnerable | Endangered | 2002 |
| Mammal | Black-footed Tree-rat | *Mesembriomys gouldii* | Endangered | Vulnerable | 2005 |
| Mammal | Pale Field-rat | *Rattus tunneyi* | - | Vulnerable | 2012 |

Table 5-12: Listed migratory species recorded in the Coomalie Region

| Common name | Scientific name | Last recorded |
|---|---|---|
| Estuarine Crocodile | *Crocodylus porosus* | 2002 |
| Swinhoe’s Snipe | *Gallinago megala* | 2005 |
| White-throated Needletail | *Hirundapus caudacutus* | 2005 |
| Fork-tailed Swift | *Apus pacificus* | 2014 |
| Rufous Fantail | *Rhipidura rufifrons* | 2002 |

Further information can be found in Chapter 12 – Aquatic Ecosystems and Chapter 14 – Terrestrial Flora and Fauna.

Feral animals

A list of feral fauna species recorded in the Coomalie region is shown in Table 5-13 and includes one amphibian, two reptile and nine mammal species. Four vertebrate species (pig, cat, rabbit and cane toad) are listed under the EBPC Act as key threatening processes to the environment. The remaining mammal species (dog, feral buffalo, cattle, horse, sambar deer, black rat) are listed as feral animals, as defined under the TPWC Act.

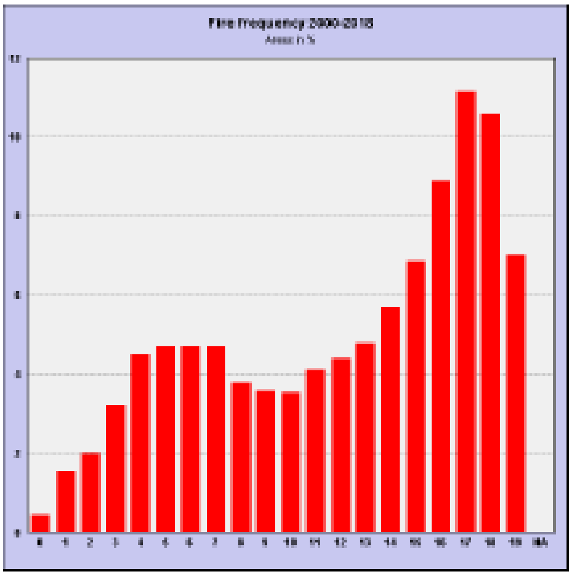
Table 5-13: Feral fauna species recorded in the Coomalie region

| Type | Common name | Scientific name |
|---|---|---|
| Amphibian | Cane Toad | *Rhinella marina* |
| Reptile | Asian House Gecko | *Hemidactylus frenatus* |
| Reptile | Flower-pot Blind Snake | *Ramphotyphlops braminus* |
| Mammal | Black Rat | *Rattus rattus* |
| Mammal | Wild Dog | *Canis lupus* |
| Mammal | Cat | *Felis catus* |
| Mammal | Rabbit | *Oryctolagus cuniculus* |
| Mammal | Horse | *Equus caballus* |
| Mammal | Pig | *Sus scrofa* |
| Mammal | Swamp Buffalo | *Bubalus bubalis* |
| Mammal | Cattle | *Bos taurus* |
| Mammal | Sambar Deer | *Cervus unicolor* |

## 5.6.4. Fire

Fire frequency has generally increased since 2000 with some regional areas being burnt with high frequency (Figure 5-14), likely contributable to the increasing fuel load resulting from invasion by Gamba Grass (Setterfield *et al.*, 2013).

Fire frequency 2000-2018




area burnt for each fire frequency category 2000-2018

| Category | Area sq km | Area% |
|---|---|---|
| 0 | 6.62 | .44 |
| 1 | 23.11 | 1.53 |
| 2 | 29.73 | 1.97 |
| 3 | 48.52 | 3.22 |
| 4 | 67.58 | 4.49 |
| 5 | 70.35 | 4.67 |
| 6 | 70.50 | 4.68 |
| 7 | 70.32 | 4.67 |
| 8 | 56.71 | 3.76 |
| 9 | 53.96 | 3.58 |
| 10 | 53.10 | 3.53 |
| 11 | 61.83 | 4.10 |
| 12 | 66.15 | 4.39 |
| 13 | 71.77 | 4.76 |
| 14 | 85.82 | 5.70 |
| 15 | 103.07 | 6.84 |
| 16 | 134.06 | 8.90 |
| 17 | 167.88 | 11.14 |
| 18 | 159.58 | 10.59 |
| 19 | 105.82 | 7.02 |

Fire frequency 2000-2018

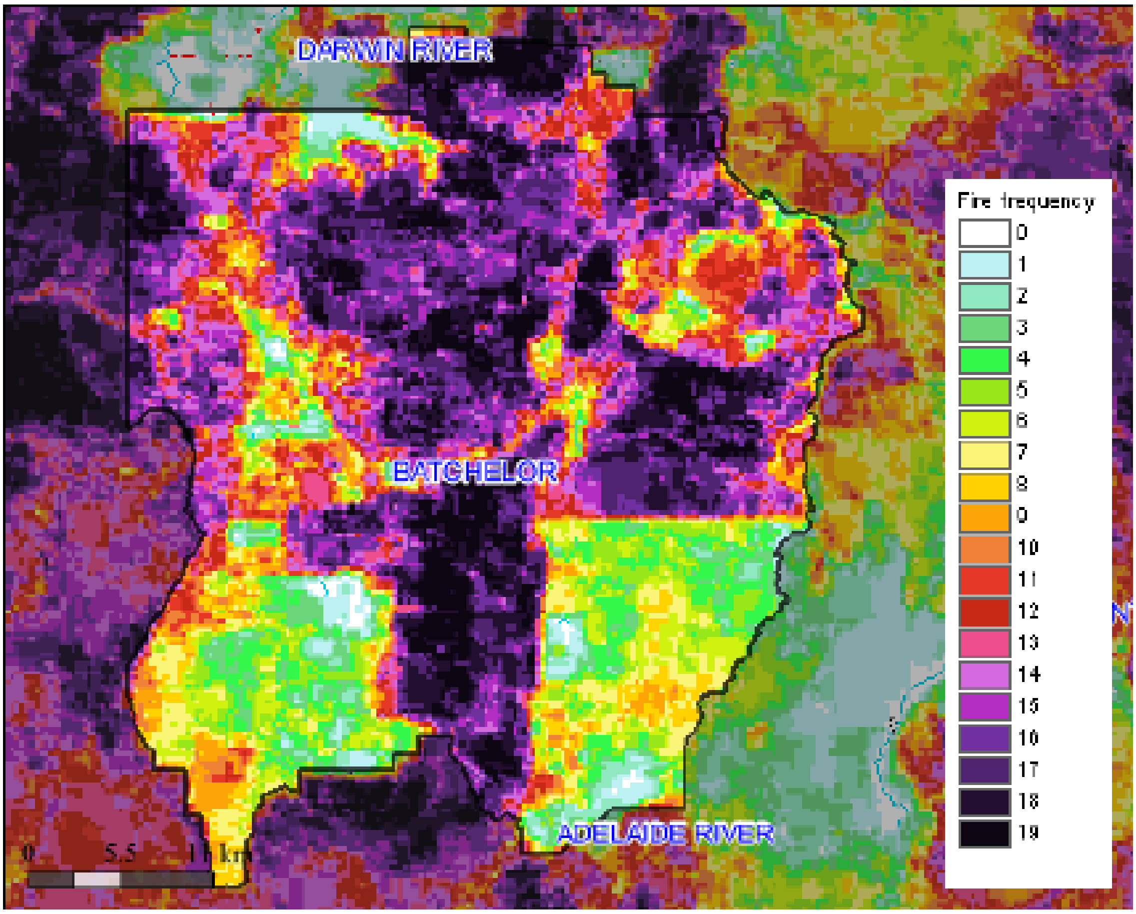



Figure 5-14: Coomalie region fire history, 2000-2008. (NRM InfoNet, 2019)

# 5.7. Regional Projects

Prior to the Rum Jungle Project commencing (in the 1950s) there were a number of historic small scale copper and tin subsistence mining operations in the Coomalie region including Bamboo Creek Tin Mine; alluvial and reef tin mining to the east of Blyth Homestead (both in Litchfield National Park) and the Rum Jungle Copper Mines (NAA: A1690, DPIE67/001811). Other resources projects that have operated in the area include the Woodcutters Mine and Giants Reef Exploration Pty Ltd's Sundance Gold Mine (reviewed in Simpson, 1995); in addition to numerous identified, but unexploited, deposits (see Korab, 2007).

Contemporarily, Rum Jungle proper (Section 2968 Hundred of Goyder) is subject to exploration leases ELR 146, EL 27007, EL 27559, EL 27560 and EL 27562 held by Northern Territory Resources (DME, 2013).

The Browns Oxide Mine site is located immediately adjacent (west) of the Rum Jungle site. The mine site consists of an open pit, processing plant, infrastructure, tailings storage facility, sediment dam and ore stockpiles. The base metals in the poly-metallic ore resource include cobalt, copper, lead, nickel and silver. It is understood that mining operations commenced in 2007 and the site entered care and maintenance in 2009 (NRETAS, 2011). The care and maintenance status of the mine remains indefinite pending completion of feasibility studies of possible mining and processing scenarios, or until the operation is sold. Current activities at the site are focused on managing, treating and discharging surface water under an approved WDL to the EBFR under stringent conditions (NTG, 2018a).

Yarram Iron Ore Project is proposed by Territory Iron Pty Ltd (a subsidiary of Territory Resources Ltd) and is located immediately west of the Rum Jungle site. Territory Iron proposes to develop, operate and rehabilitate an open pit iron ore mine over 18 years, exporting approximately 11 Mt of iron ore; it is yet to be approved by the NT EPA (NT EPA, 2018b) or DoEE (Ref: EPBC 2018/8371).

Central Agri Group has refurbishment the Batchelor Abattoir (and feedlot) to enable export of boxed chilled and frozen product (cattle, buffalo) to Asia (*ABC*, 2018). The plant has the capacity to process 160 cattle *per* day and is expected to re-open for business on 3 December 2019, employing up to 40 people (NT EPA, 2019a).

# 5.8. Cumulative Impacts

The physical changes to the landscape at Rum Jungle and the widespread historic and ongoing site and downstream contamination have compromised several environmental and cultural values. This section aims to summarise and provide a brief assessment of the expected cumulative impacts to the receiving environment should this project be undertaken. Considerations have be made for the impacts of the proposal's main objectives and for the potential cumulative impacts of future developments.

## 5.8.1. Cumulative Impacts in the Aquatic Landscape

Potential cumulative impacts to the receiving environment should this project be undertaken are considered to be positive gains for the environment. The project is expected to facilitate a substantial reduction during the Construction phase in the extent of AMD-impacted groundwater due to operating the SIS and recovery bores in the Copper Extraction Pad area and former ore stockpile area (Chapter 10.6). The extent of the simulated $SO_4$ and Cu plumes is expected to be further reduced after the active AMD sources onsite (the WRDs and shallow backfill materials in Dyson's (backfilled) Pit) have been removed. The SIS bores are predicted to recover more than 1000 t/yr $SO_4$ in Years 1, 2, and 3 of operation.

The rate of reduction of Cu loads in the system will be much slower than for $SO_4$, since Cu movement in groundwater is dependent on the rate of desorption/dissolution of Cu from the rock matrix. The SIS bores are expected to recover 6 to 8 t/yr Cu in Years 1 to 8 of operation and slightly less in Years 9 and 10 as Cu concentration within the groundwater declines. The average annual Cu load recovered during the Construction phase is expected to be 6.6 t/yr. This load is approximately twice the observed Cu load in the EBFR for current conditions which can be attributed to the expected high Cu loads to be recovered from the Copper Extraction Pad area.

Groundwater quality in Dyson's Area is not predicted to start to improve until waste rock from Dyson's WRD and shallow backfill materials from Dyson's Pit are re-located and groundwater in this area begins to be diluted and eventually flushed by rainfall without an AMD source present.

These cumulative impacts are expected to result in positive outcomes for the downstream aquatic environment in the EBFR by reducing contamination loads reporting to the system.

### 5.8.2. Cumulative Impacts in the Terrestrial Landscape

In conjunction with the expected positive cumulative impacts in the aquatic environment, project activities are also expected to deliver a net positive impact on the terrestrial environment following the completion of extensive revegetation of landforms onsite. Historic mining and rehabilitation activities have altered the landscape within the former Rum Jungle Uranium Field, most prominently seen at the Rum Jungle site. Future rehabilitation will see a final landscape that, whilst still altered, has improved functionality and reduced environmental and cultural impact. While short-term impacts of land clearing have been minimised to the greatest extent it is the long-term cumulative impacts of the extensive revegetation plan that establish the greatest positive outcome for the terrestrial environment. Following the completion of the revegetation plan onsite the project aims to deliver approximately 145 ha of revegetated land improving ecological possess in the area.

### 5.8.3. Cumulative Impacts on Future Projects

As noted above the EBFR is impacted by AMD originating from the Rum Jungle site. In the event that the Browns Oxide Mine or the Yarrum Iron Ore project are granted approval for development, their impact assessment will need to consider the impacted EBFR water quality and the degree of implementation of this rehabilitation plan. As it stands, the degree of impact due to AMD significantly outweighs any contribution of metal load made to the river by the Browns Oxide Mine which is currently under Care and Maintenance and it is unlikely that release of poor water quality would be permitted from these sites under their WDLs. Considerable work has been done by the project to develop a set of LDWQOs for the EBFR and this work could be utilised by future developments to incorporate into design and planning.

### 5.8.4. Summary of Cumulative Impacts

Considering the unique nature of this EIS and project proposal, the cumulative impacts to the receiving environment have formed the foundation of the project design and the project objectives. Key rehabilitation aims for the Rum Jungle Mine site are creating a safe and stable environment and reducing offsite impacts. Significant consideration has been made for the impacts to the receiving environment with the view of maximising any potential positive gain where possible and delivering a final positive outcome for both terrestrial and aquatic environments.

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# 6. Existing Environmental Condition

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## 6.1. Overview

The Rum Jungle Project operated between 1953 and 1971 and produced 3,530 t of uranium oxide and 20,000 t of copper concentrate, as well as some nickel and lead products. The former mining and processing operations resulted in legacy landform, groundwater and surface water contamination, including significant AMD and impact to the EBFR. Further site history is summarised in Chapter 1 - Introduction.

The Rum Jungle site and downstream environment have been the subject of numerous phases of investigation and rehabilitation since the late 1970s, with the most significant rehabilitation works implemented between 1983 and 1986. A summary description of historic and recent investigation literature is located within the Appendix - this is an invaluable repository of learnings for the rehabilitation of mines in tropical Australian environments.

Since 2009, the NTG (through DPIR or its predecessor departments) and the Australian Government have been working under a National Partnership arrangement to deliver site maintenance and continued environmental monitoring. The results of these programs have been used to develop an improved rehabilitation strategy that is consistent with the views and interests of Traditional Owners and that meets contemporary environmental and mined land rehabilitation standards.

The NT EPA's *Northern Territory Contaminated Land Guideline* (2017) provides a framework for contaminated site assessment. The mineralised provenance and history of contamination and rehabilitation at the Rum Jungle site provides a complex baseline from which to assess site contamination under conventional frameworks. A long history of investigation and study have informed a sound understanding of priority contamination processes at Rum Jungle. In addition to contamination impacting Environmental Values, Cultural Values have been impacted affected by landscape alteration caused by historic mining activities. This EIS presents elements of the contamination assessment and this chapter presents:

- A summary of the existing site conditions including mining landforms, areas of disturbance, summary of hydrological processes modified by historic mining and mine waste volumes.

- A list of compromised environmental values associated with historical/legacy impacts and current site conditions, including cross-reference to other components of this EIS that describe particular impacts in greater detail (Section 6.2).
- A summary Conceptual Site Model summarising key pollutant sources and effects caused, or risks posed, by those sources (Section 6.3).

The current condition of site and downstream ground and surface water hydrology and quality are described, in detail, in Chapter 10 – Inland Water Environmental Quality and Chapter 11 – Hydrological Processes; they will only be covered briefly in this chapter.

### 6.1.1. Site Description

Historic mining and rehabilitation activities have altered the landscape within the former Rum Jungle Uranium Field, most prominently seen at the Rum Jungle site. Future rehabilitation will see a final landscape that, whilst still altered, has improved functionality and reduced environmental and cultural impact. The Rum Jungle complex is a typical example of an open pit legacy mining site of which there are many examples across Australia's landscape. Rum Jungle features, such as open pits and WRDs are shown in Figure 6-1; physical dimensions of all features across the Rum Jungle, Mt Burton and Mt Fitch sites are summarised in Table 6-1.

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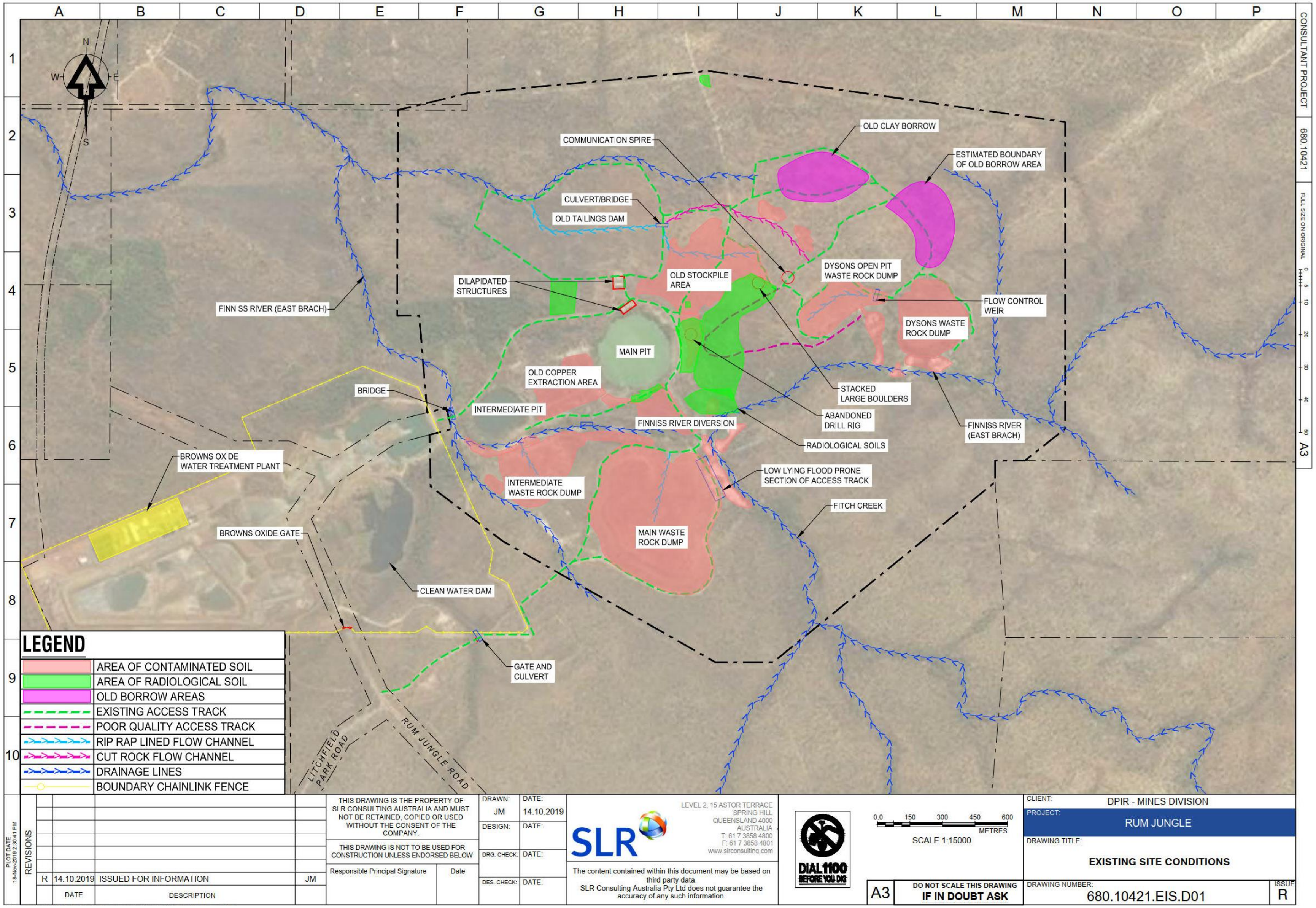



Figure 6-1: Existing features at the former Rum Jungle Mine site

Table 6-1: Mining landscape features, dimensions and history

| Feature | Brief History | Horizontal Area ($m^2$) | Maximum Height/Depth (m) | Volume ($m^3$) |
|---|---|---|---|---|
| Main Pit | Open pit mined for Uranium. From 1965-1971 approx. 700,000 t of tailings was discharged into the Main Pit from the northern perimeter. | 100,243 | 110 m to base of Pit.<br>47 m to top of backfilled tailings | 3,530,000 *(original) |
| Intermediate Pit | Open pit mined for Copper. | 41,882 | 55 | 1,087,000 *(original) |
| Dyson's (backfilled)Pit | Open pit mined for Uranium, then used for tailings storage (approx. 600,000 t discharged 1961-1965). During 1980s rehabilitation it was backfilled with tailings from the Tailings Dam and copper ore from the Copper Extraction Pad. | 58,450 | NA | 917,000 (original) |
| Main WRD | Storage of waste rock from Main Pit. | 958,575 | 21 | 4,750,000 |
| Intermediate WRD | Storage of waste rock from Intermediate Pit. | 253,875 | 13 | 819,225 |
| Dyson's WRD | Storage of waste rock from Dyson's Pit. | 87,547 | 21 | 1,258,000 |
| Old Tailings Dam | During historic mining operations, un-neutralised mill tailings discharged to this area over natural surface. Area was stripped of tailings and contact soils during 1980s rehabilitation; claimed materials disposed of in Dyson's Pit. | 308,165 | NA | NA |
| Old Copper Extraction Area | Area used as copper leach pad. Ore stripped in 1980s rehabilitation and disposed of in Dyson's Pit. | 116,250 | NA | NA |
| Old Stockpile Area | Run of Mine ore stockpile - stripped and covered during 1980s rehabilitation | 195,381 | NA | NA |
| Old Borrow Area | Several on site used for 1980s rehabilitation | 126,000 | NA | NA |
| Mt Burton Pit | Open pit mined for Uranium | 7,490 | | NA |
| Mt Burton WRD | Storage of waste rock from Mt Burton Pit | 13,893 | 5 | 105,000 |
| Mt Fitch Pit | Open pit explored for Uranium. No ore abstracted – overburden was stripped. | 6,608 | NA | NA |
| Mt Fitch WRD | Stockpiled overburden from Mt Fitch Pit | 7,000 | 11 | <10,000 |
| Radiological Soils | Areas where Uranium ore was stockpiled and milled/processed | 154,900 | NA | NA |

**Original pit volumes after Verhoevan (1988)*

## 6.1.2. East Branch Finniss River Diversion

Historic mining operations diverted the EBFR from its original course. Figure 6-1 shows the current flow paths across the Rum Jungle site including the current EBFR diversion channel to the south of Main and Intermediate Pits. The original flow path of the EBFR is shown in Figure 6-2. Additional information can be found in Chapter 10 – Inland Water Environmental Quality and Chapter 11 – Hydrological Processes.

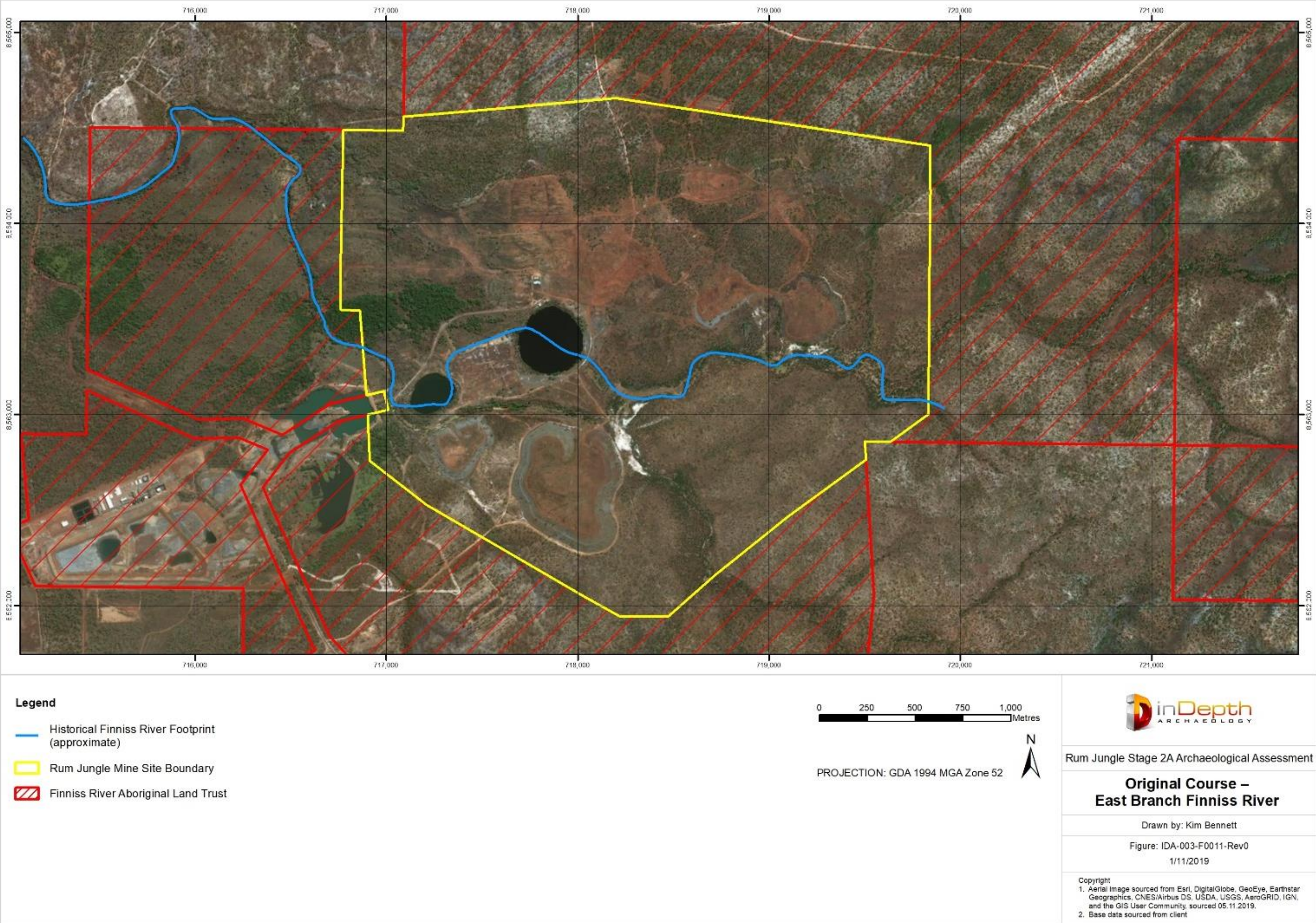



Figure 6-2: Original course of the East Branch Finniss River (EBFR)

## 6.2. Compromised Environmental Values

The physical changes to the landscape at Rum Jungle and the widespread historic and ongoing site and downstream contamination have compromised several environmental and cultural values. These are described in the following sections and in other Chapters of this EIS as outlined below.

### 6.2.1. Background

The assessment of site contamination in accordance with the ASC-NEPM (NEPC, 2013) considers that air, land and water (including groundwater) constitute segments of the environment (or environmental media) that are evaluated to determine the condition of a particular site in comparison to background conditions or to conditions deemed suitable for a particular beneficial or end use  A wide range of environmental values (or beneficial uses) may be reliant on the condition of one or all segments of the environment.

The extent to which environmental values have been compromised by the impact to environmental media is a concept used in environmental remediation practice, as this approach allows the development of accurate site investigation and remediation strategies.  The establishment of a defined set of compromised environmental values and the development of conceptual site models that describe the critical contamination linkages can distil remediation project objectives and approaches.

In the case of the Rum Jungle Mine site, the following environmental values are considered to be compromised by impact caused at the site and downstream of the site:

- Ground and surface water quality onsite and as a secondary source of impact to the EBFR – refer Chapter 10 – Inland Water Environmental Quality
- Aquatic ecosystems of the EBFR – refer Chapter 12 – Aquatic Ecosystems
- Terrestrial flora and fauna (onsite and within downstream EBFR environs) – refer Chapter 14 – Terrestrial Flora and Fauna

- Human health and safe site access for the long-term – refer Chapter 15 – Human Health and Safety
- Cultural heritage and values protection – refer Chapter 8 – Historic and Cultural Heritage
- Social and amenity value of the site and of the project area – refer Chapter 13 – Social and Economic Impact.

The primary site and downstream Contaminant of Concern is copper resulting from AMD; however other less impactful contaminants to also be discussed here include other heavy metals resulting from AMD, low pH waters resulting from AMD, historically contaminated radiological soils, Asbestos Containing Materials (ACMs) and sulphate salt impacted soils. Rehabilitation objectives are outlined in Chapter 1 - Introduction.

## 6.3. Summary Conceptual Site Model

This section provides a summary Conceptual Site Model under sub-headings associated with the various sources and types of environmental contaminants presented within surface soils and current landforms located at the Rum Jungle site. This chapter will focus on sources and pathways with receptors elaborated in subsequent Chapters. Each Chapter describes the existing site condition including impacts due to historic mining practices and subsequent long-term contamination processes. The most significant contamination mechanism at the Rum Jungle site is the impact to ground and surface waters by AMD. The primary AMD sources are sulphide-bearing waste rock in the historic WRDs and leached low-grade ore and contaminated soils placed in shallow zones of Dyson's Pit during initial rehabilitation in 1984/1985. Groundwater quality in some areas is further degraded by AMD from sources that were eliminated during the 1980s rehabilitation works and by metalliferous liquor lost during an experimental heap leach operation from 1965 to 1971 in the Copper Extraction Pad area. Chapter 10 – Inland Water Environmental Quality of this EIS and associated Appendix documents describe in detail the AMD processes for the Rum Jungle site.

Groundwater conditions are simulated with a Numerical Groundwater Model that consists of a Transient Flow Model and Solute Transport Model. A Water and Load Balance Model was been developed to simulate stream flows (discharge) and sulphate ($SO_4$) and copper (Cu) concentrations in the EBFR. Detrimental effects of elevated metals due to AMD on aquatic ecosystems in the EBFR and other downstream environmental values are detailed in the report *Rum Jungle Impact Assessment* (Hydrobiology, 2016b – see Appendix). Aquatic ecosystems are described in Chapter 12 – Aquatic Ecosystems.

The *Rum Jungle Impact Assessmen*t report (Hydrobiology, 2016) describes the LDWQOs for the EBFR (and Finniss River) which have been established as rehabilitation objectives. Copper concentrations is one of the few metals that exceeds LDWQOs during the Wet season when flows in the EBFR are highest and dilution of contaminants in the system is at its peak. Copper is consequently considered the primary Contaminant of Concern in the EBFR and lowering concentrations below the LDWQO is a key rehabilitation objective. Sulphate is a focus of Chapter 10 – Inland Water Environmental Quality because it is transported near-exclusively in groundwater and is therefore a reliable indicator of AMD impacts in groundwater down gradient of the WRDs and Dyson's (backfilled) Pit, and in the EBFR.

Relative to AMD related impacts at Rum Jungle and downstream, the radiological and asbestos impacts are relatively minor; however their sources are discussed in this section.

### 6.3.1. Waste Rock

The waste rock AMD processes at the Rum Jungle site are the most significant contributor to copper contamination both onsite and to the downstream EBFR *via* surface and groundwater pathways. Robertson GeoConsultants (RGC) and David Jones Environmental Excellence (DJEE) (RGC and Jones, 2019 – see Appendix) provide a comprehensive assessment of waste rock in the WRDs and Dyson's (backfilled) Pit based on field investigations in 2014 and data from previous geochemical investigations and routine seepage water quality monitoring. AMD impacts to groundwater and the EBFR have been intensively characterised and monitored by the Proponent since recent rehabilitation planning was initiated in 2010.

Sulphide-bearing materials onsite are classified as either PAF (Potentially Acid Forming) or NAF (Non Acid Forming), with PAF-I having the highest potential and PAF-III having the least, as based on conventional Acid Base Accounting (ABA). Additional testing was also undertaken to determine the existing acidity content of the sulphide-bearing materials that is related to the oxidation that has occurred *in situ* and since these materials were originally mined and stored within the WRDs in the 1950s and 1960s (see RGC and DJEE, 2019, and references therein).

PAF-I materials are predicted to generate the most AMD due to their higher sulphide content and low Acid Neutralising Capacity (ANC). PAF-II and PAF-III materials are also predicted to generate substantial AMD and therefore also require containment to prevent sulphide oxidation or mitigate potential impacts down gradient. Further details on best practice approaches to AMD prevention and/or mitigation are provided in the Leading Practice Sustainable Development in Mining Series AMD Handbook (DIIS, 2016).

The waste rock materials at Rum Jungle have been well characterised over time. As described in the *Rum Jungle Minesite Physical and Geochemical Characteristics of Waste Rock and Contaminated Materials* (Robertson

GeoConsultants and Jones, 2019 – see Appendix), approximately 85% of the volume of waste rock at the Rum Jungle site is PAF. Figure 6-3 is a graphical representation of the PAF waste rock characterisation across site by current storage location. A high proportion of all waste rock stored at the site is PAF-I. It is important to note that each pie chart represents a storage facility though stored volume at each facility varies.

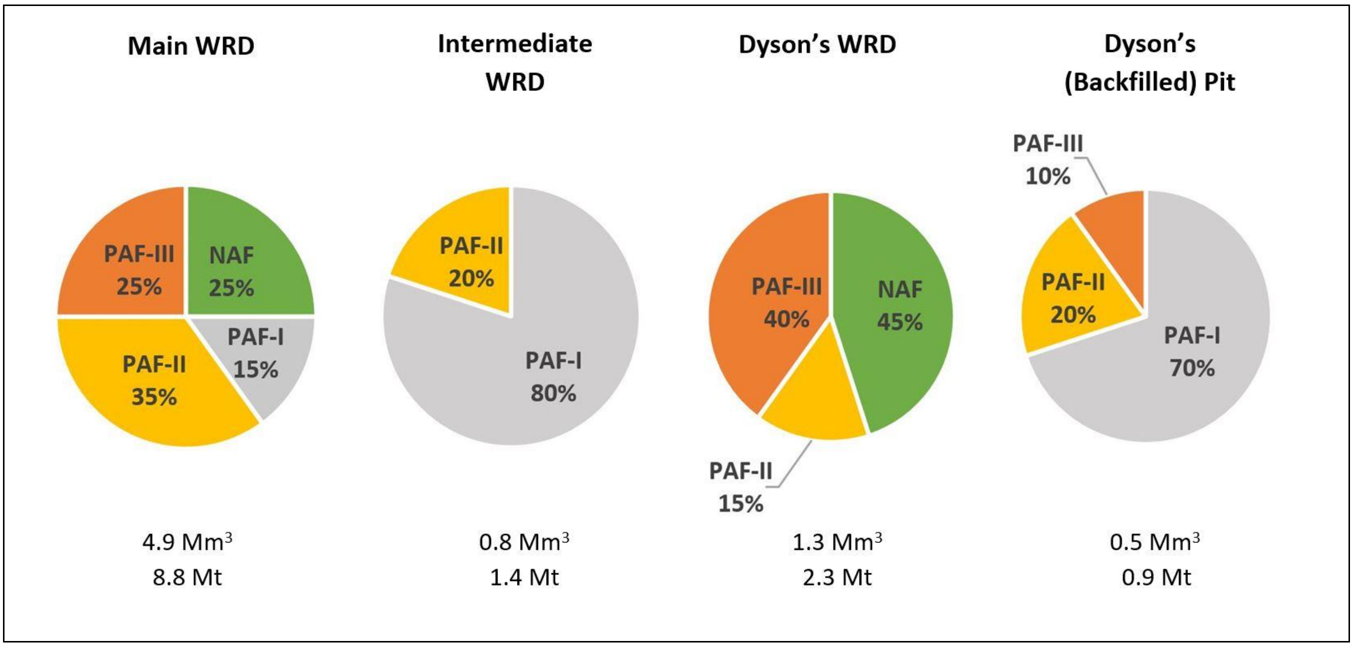



Figure 6-3: Distribution of PAF materials by current waste storage location on the former Rum Jungle Mine site

Chapter 10 – Inland Water Environmental Quality describes in detail the AMD contamination sources and pathways; this is succinctly captured in the following example copper balance flow chart for current site conditions for the 2013-14 water year produced by RGC (2019) (see Figure 6-4).

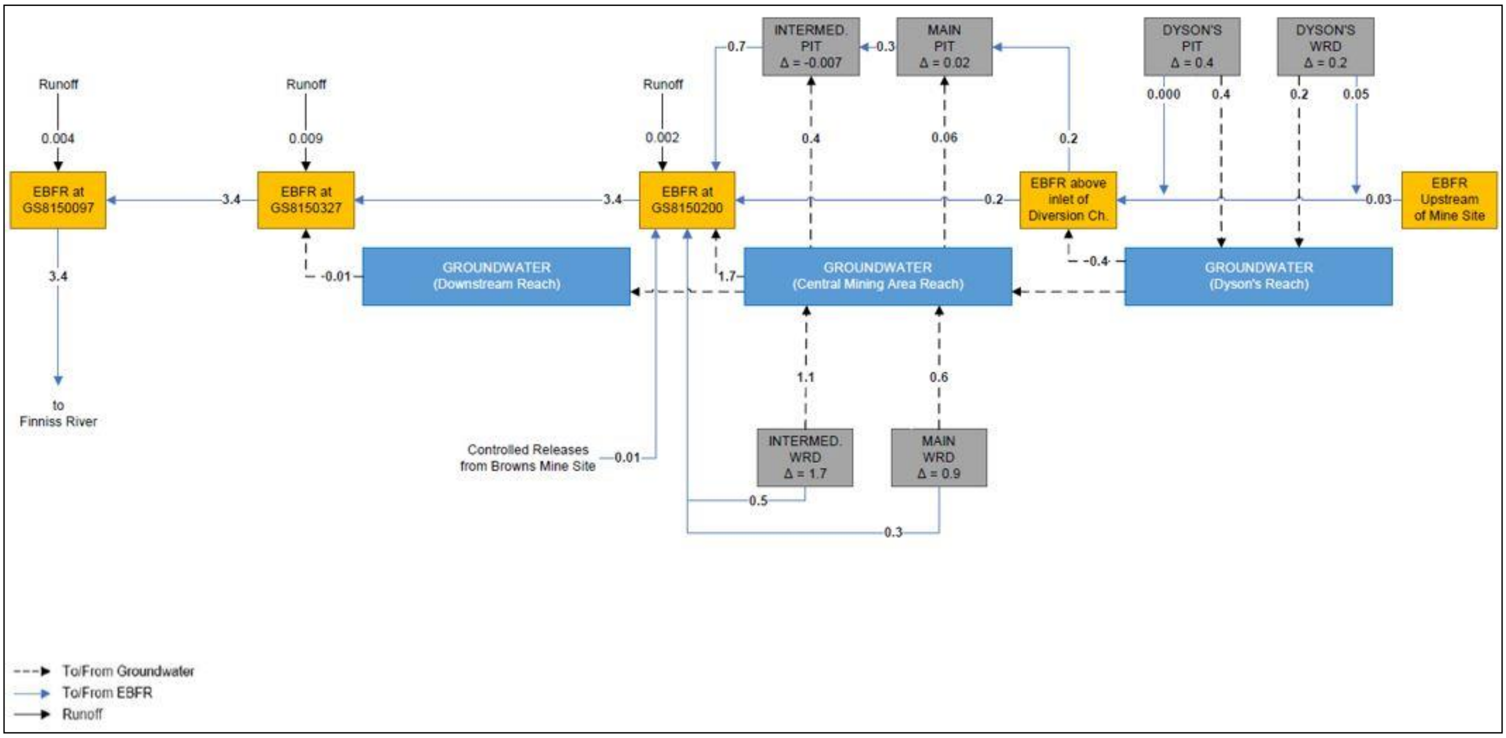



Figure 6-4: Current conditions – Copper (Cu) balance: Actual load (t/yr) 2013-14 water year (RGC, 2019)

The contribution of copper loading to the EBFR varies across the site, however the majority of this load is sourced from the Intermediate WRD and Main WRD reaches as described here in **Figure 6-5** produced by RGC (2019). These reaches correspond to the largest volume of PAF-I and PAF-II storage onsite at the Main and Intermediate WRDs.

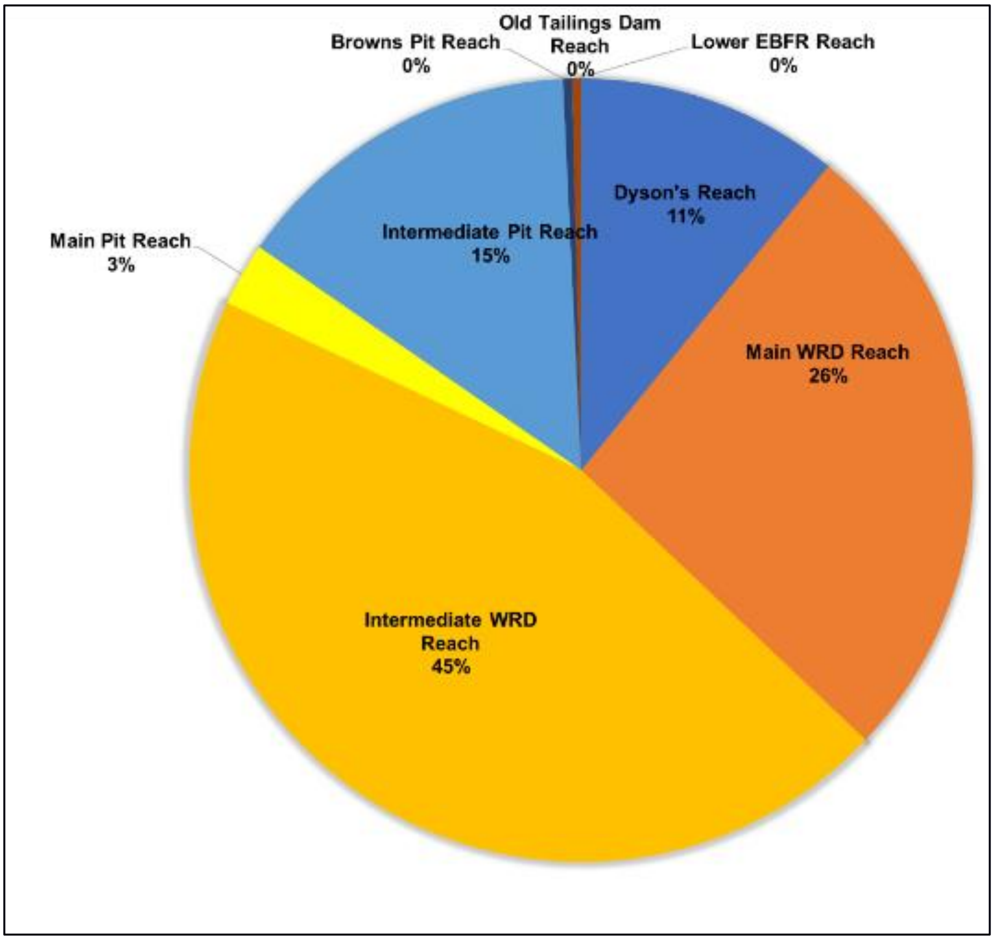



Figure 6-5: Copper (Cu) load to EBFR by Rum Jungle Mine reach (RGC, 2019)

For the purpose of Stage 3 worker safety, all waste rock stockpiles onsite are to be treated as a low radiological hazard as all waste rock contains Naturally Occurring Uranium Material (NORM) from the uranium (or copper) ore body from which they were mined. This is discussed in Chapter 16 – Radiation.

The AMD derived ground and surface water contamination concentrations are well studied. Groundwater impacts are summarised in Chapter 10 – Inland Water Environmental Quality and surface water impacts are summarised in Chapter 11 – Hydrological Processes and Chapter 12 – Aquatic Ecosystems.

## 6.3.2. Historic Tailings

The history of tailings disposal across site and the early tailings rehabilitation methodologies are described in several reports. According to reporting by Davy (1975), tailings were deposited in several locations across site during the operational phase of the former mine and portions were subsequently relocated during the 1980s rehabilitation works (Allen and Verhoeven, 1986) as follows:

- Un-neutralised tailings were discharged across the Old Tailings Dam area during operations and subsequently relocated with subsoils to the Dyson's Pit backfill during the 1980s rehabilitation works. (Allen and Verhoeven, 1986).
- Minor volumes of residual tailings remain below portions of the cover system at the Old Tailings Dam footprint.
- Un-neutralised tailings were disposed into the Main Pit during 1965-1971 operations. Approximately 700,000 t of tailings were discharged; the tailings remain *in situ*.

- Un-neutralised tailings were disposed into the Dyson's Pit during 1960s operations. It is estimated that 600,000 t of tailings were discharged; the tailings remain *in situ*.

All tailings are currently stored below cover systems at the Dyson's (backfilled) Pit or submerged underwater in the Main Pit. Figure 6-6 shows a model of the current storage condition within the Main Pit where the deposited tailings (orange) are stored below water (blue) within the Pit shell. Tailings were discharged into this pit from the northern wall during operations and it is likely that the backfilled (orange) surface that extends above the water line to the north is also made up of waste rock materials. The submerged and covered tailings materials are currently isolated from environmental receptors under a significant water column and do not appear to be contributing to copper contamination loads across site.

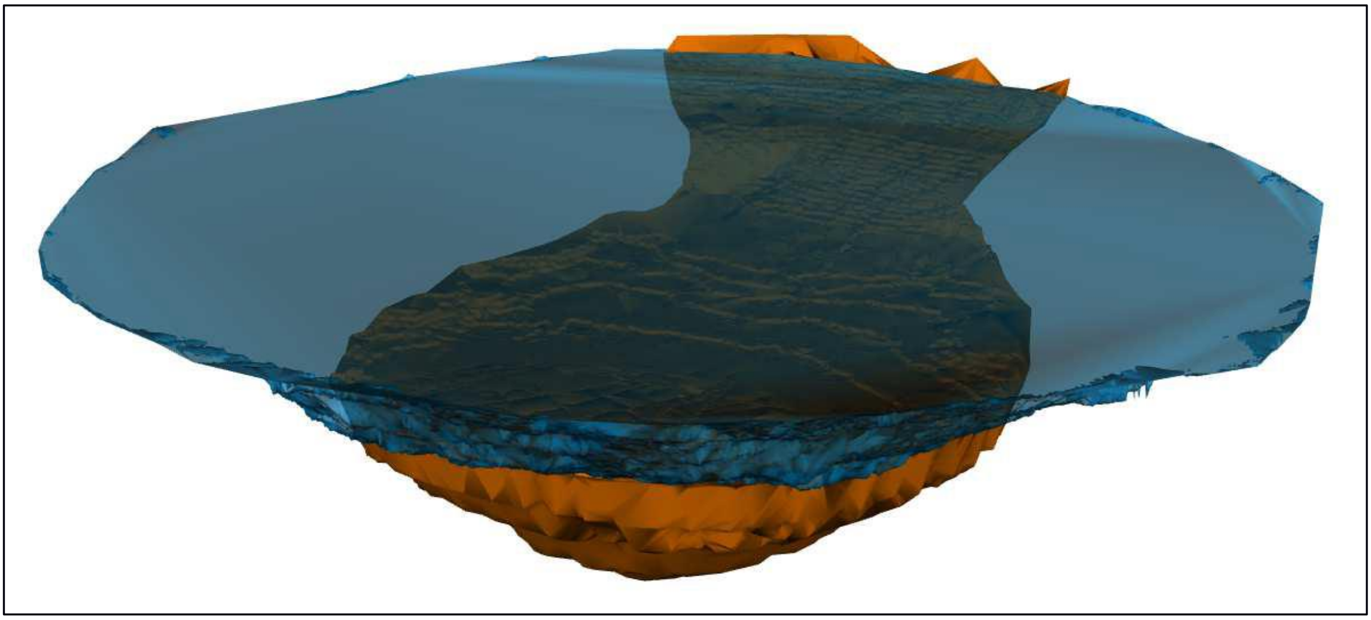


Figure 6-6: Model view to North of Main Pit backfilled tails (orange) and water cover (blue) (RGC, 2016)

## 6.3.3. AMD-Impacted Groundwater

Groundwater and surface water quality at the site is affected by AMD generated from the sulphide-bearing waste rock of the existing WRDs and by other areas of historical operation, such as the experimental heap leach operations conducted at the Copper Extraction Pad. In effect, impacted groundwater beneath particular parts of the site is a significant secondary source of AMD and represents a key contributor to AMD impacts in the EBFR.

A detailed description of groundwater quality impacts and the resultant impacts of both direct WRD seepage and impacted groundwater contribution to EBFR streamflow is provided in Chapter 10 - Inland Environmental Water Quality. The following Figure 6-7 shows an example of Dry season surface water quality in the EBFR diversion channel adjacent to the Intermediate WRD.

Figure 6-7: Basal flow in EBFR diversion channel adjacent to the Intermediate WRD

## 6.3.4. Contaminated Soils

Beyond principal sources of contamination affecting the EBFR (WRDs and AMD-impacted groundwater), significant tracts of land affected by mine operations also require remediation or rehabilitation in order to achieve the overall project objectives. The identification and evaluation of risks posed by ‘contaminated soils’ is somewhat confounded by the presence of naturally elevated background concentrations of several metallic elements in regional soils borne from the highly mineralised underlying parent geology of the Rum Jungle Complex. However, unacceptable soil contamination or soil conditions exist in several areas as discussed by primary contaminant type below.

***Copper contaminated soils***

A range of elevated metal concentrations, in particular copper, remain in subsoils and/or have migrated into previously placed cover soils at the Old Tailings Dam, Copper Extraction Pad and through cover systems placed over WRDs. Presently, the Dyson’s (backfilled) Pit and the Copper Extraction Pad do not support vegetation which was determined to be the result of acidity and metal phytotoxicity (Menzies and Mulligan, 1997). Vegetation dieback effects are partially and varyingly attributable to the legacy of low soil pH and the increased solubility of eco-toxic heavy metals, including copper, manganese, zinc and aluminium under acidic soil conditions in these areas. Other elements critical to vegetation health also become less bio-available at lower soil pH, including phosphorous and calcium (Ryan, 1985).

There is less evidence for widespread vegetation dieback related to low pH and elevated metals across the Old Tailings Dam, however there are small pockets of low pH areas across this facility and poor vegetation recovery.

In addition to elevated metal concentrations, vegetation dieback across much of the site is related to the lack of a self-sustaining topsoil structure and regular uncontrolled fire which is exacerbated by the historical introduction of foreign grass species.

<u>Old Tailings Dam Area</u>

Between 1954 and 1961, tailings were discharged onto approximately 33 ha of low-lying land which was bunded to form the ‘Old Tailings Dam’ area. Tailings were only partially impounded by a series of shallow embankments near Old Tailings Creek and a significant quantity of tailings were reportedly eroded into the Finniss River system during Wet season inundations (Davy, 1975). In the 1984 Dry season, approximately 330,000 $m^3$ of remnant tailings and contaminated subsoils were re-located from the Old Tailings Dam into the pre-drained Dyson’s Pit. Although rehabilitation designs intended that subsoils be removed to a depth of 0.3 m below the base of tailings, other reports suggest that on average only 0.2 m was over-excavated. Residual contaminated subsoils remained and hydrated lime was ploughed into the area at an average rate of 8 tonnes *per* ha, prior to the placement of a gravelly topsoil cover to an average depth of 0.3 m. This achieved measured saturated paste pH ranging from 6.1-7.2 in the top 0.45 m of cover (Ryan, 1985).

The cover materials were sourced from neighbouring borrow areas; Borrow Area 3 immediately west of the Old Tailings Dam and Borrow Area 5 north of Dyson’s Pit. The cover materials imported from Borrow 3 may have been exposed to eroding or overtopping tailings liquor as the site is immediately down gradient and adjacent to the Old Tailings Dam area. In December 1984 the Old Tailings Dam area was seeded with a mixture of exotic grasses and legumes, and fertilised to supplement the low soil nutrients (Ryan, 1986). That vegetation was successfully propagated for several years prior to declining maintenance attention. Presently, the vegetation quality on this surface is relatively poor as patchy grassland. This poor vegetation recovery is likely to be linked to frequent uncontrolled fire events, poor soil biological and structural properties, Gamba Grass infestation and potential residual soil acidity effects though this has not been recently confirmed.

Copper Extraction Pad

An experimental heap leaching operation was conducted in the Copper Extraction Pad area from 1965 to 1971 (see Chapter 10 – Inland Water Environmental Quality). The heap leaching process initially involved piling low-grade (< 2% Cu content) sulphide ore from the Intermediate ore body onto a low-permeable pad and then spraying the top of the pile with an acidic (pH 2) mixture of mill process water, barren liquor and pit water from the Main Pit. Liquor drained from the sulphide pile (nominally pH 1.5) was then pumped onto a pile of oxide ore to leach additional copper before the pregnant liquor was pumped to launders for copper recovery by cementation (see Davy, 1975 for further details). Rehabilitation of the Copper Extraction Pad area in 1985 involved the removal of an estimated 270,000 $m^3$ of remaining copper ore, plastic liners and a nominal subsoil depth of 0.6 m to Dyson's Pit; where it was placed above a geotextile and a 1 m thick rock blanket constructed over the previously deposited tailings. The Copper Extraction Pad was rehabilitated with a four layer cover system to a total depth of 0.9 m (McNamara, 1983; Ryan, 1986).

Assessment of Risks Posed by Current Metal Contamination of Shallow Soils

CSA Global (CSA Global, 2011 – see Appendix) characterised the distribution of metals in surface and near surface soils, fluvial sediments and some deeper soil and waste material profiles. The works involved the collection and analysis of soils by field X-ray Fluorescence (XRF) and supporting laboratory analyses to calibrate XRF results. A series of 'Cut-off' or 'Threshold' values were selected to distinguish between naturally elevated metallic elements of the Rum Jungle site and areas of soil contamination for the purpose of preliminary screening. These 'Cut-off Values' are presented in Table 6-2 below.

.

In order to benchmark current soil conditions and to evaluate the suitability of proposed rehabilitation cover materials in terms of potential human health risks, GHD and DPIR developed a series of plausible end land use scenarios and a range of assumptions to quantify human exposure rates to potential soil contaminants. Although only generalised future land uses can be defined, factors that have direct and varying implications on health risk assessment calculations (*e.g.* duration of occupation, incidental soil ingestion rates) were calibrated to incorporate higher levels of conservatism. These exposure scenarios are conservative when compared to the current post-rehabilitation Land Use Plan for site (Figure 6-8). By incorporating this conservatism, the requirement to define exact future land use modes is diminished and any improved understanding of forward land use patterns can be used to reduce these levels of precautionary conservatism. GHD have prepared a report (GHD, 2019d - see Appendix) that develops modified Health Investigation Levels (HILs) for metal concentrations in soil based on the following predicted future land uses. HILs are investigation levels or concentrations of contaminants in soils above which further appropriate investigation and evaluation will be required (NEPC, 2013). The land use scenarios assessed by GHD (2019d) are:

- **Temporary occupation**: Infrequent but possibly temporary site occupation, primarily by Traditional Owner groups. Envisaged modes of land use may include temporary gatherings, recreational, ceremonial or cultural events, contemplative activities and the practice of bushfood gathering, including from watercourses (which may or may not be permitted).
- **Occasional site visits** (no occupation and not involving bushfood gathering): primarily by Traditional Owner groups, for gatherings, meetings, recreational, ceremonial or cultural events or contemplative activities.
- **Site maintenance:** site monitoring, and care and maintenance by Rangers or land management specialists.

Continuing consultation with Traditional Owners and all project stakeholders will allow confirmation or revision of potential future site uses, but as suggested above, the definition of land use is probably less important than more specifically defining the details of activities; or the details of acceptable (and enforceable) land use restrictions under each land use scenario.

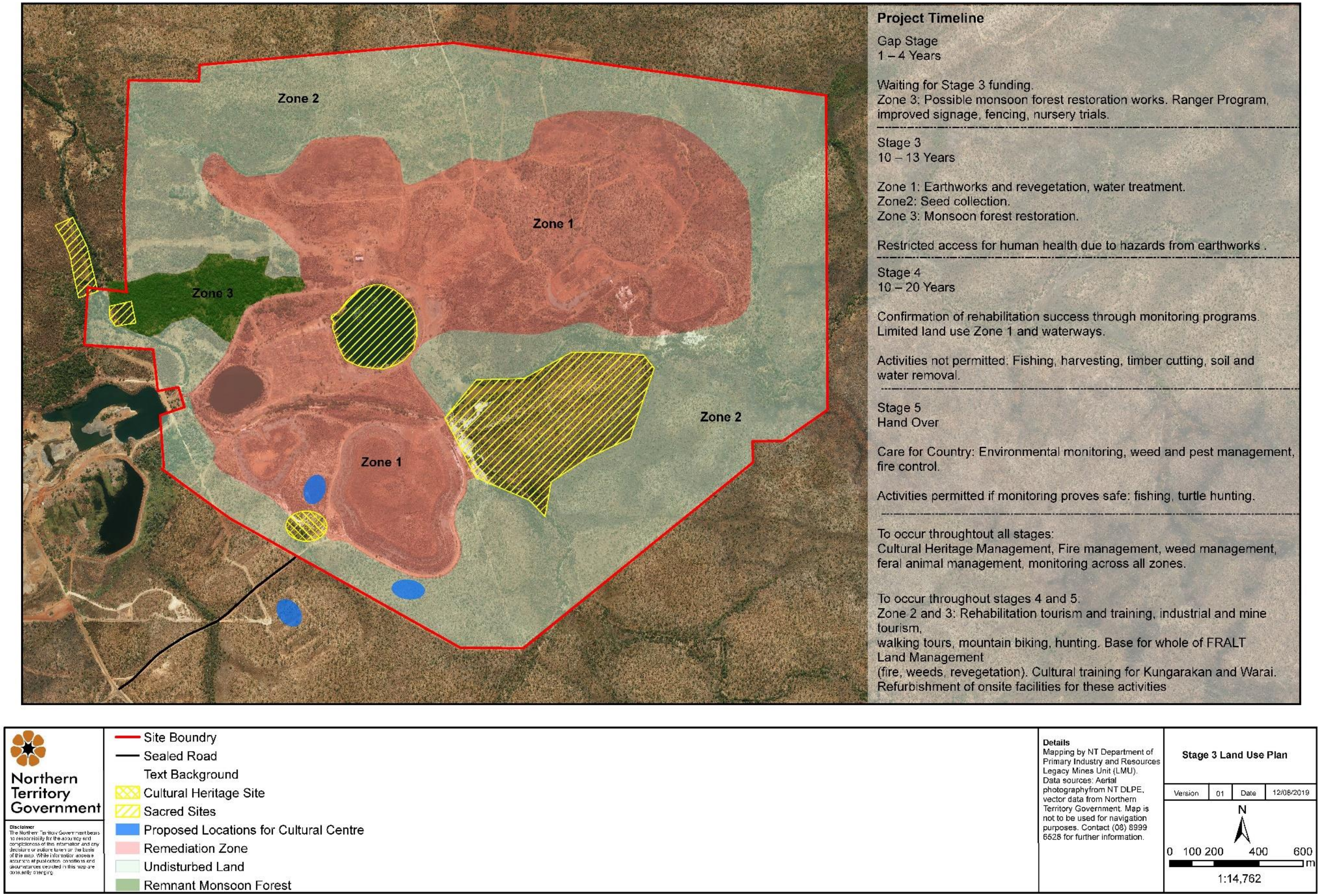



Figure 6-8: Current Land Use Plan

Table 6-2: Comparison of modified HILs and background soil 'Cut-Off Values' (mg/kg) (adapted from GHD, 2019)

| **Chemical** | **Site specific criteria for temporary occupation (modified HIL-C)** | **Site specific criteria for site maintenance (modified HIL-D)** | **'Cut-off' Values' [1]** |
|---|---|---|---|
| Arsenic | 700 | 700 | 200 |
| Beryllium | 400 | 400 | |
| Boron | 50,000 | 50,000 | |
| Cadmium | 100 | 100 | |
| Chromium (VI) | 600 | 640 | 300 [2] |
| Cobalt | 800 | 800 | |
| Copper | 44,000 | 43,000 | 2,000 |
| Cyanide (free) | 1,400 | 1,400 | |
| Iron | | | 15 % |
| Lead | 300 | 300 | **1,000** |
| Manganese | 7,500 | 8,000 | **7,000** |
| Mercury (inorganic) | 300 | 250 | |
| Methyl mercury | 36 | 35 | |
| Nickel | 870 | 900 | **600** |
| Rubidium | | | 200 |
| Selenium | 2,000 | 2,000 | |
| Strontium | | | 50 |
| Uranium | | | 100 |
| Vanadium | 1,400 | 1,500 | 350 |
| Zinc | 80,000 | 80,000 | 3,000 |

*[1]Previously estimated metal 'Cut-off Values' for background and contaminated soils (CSA Global, 2011).*

*[2]Chromium Cut-Off Value was developed for total Cr, rather than the less naturally prevalent Cr VI valency, which presents higher toxicity to humans and is therefore used in the site specific HIL calculations.*

CSA Global background 'Cut-Off Values' that are greater than 50% of the site specific HILs derived for the Rum Jungle site are shown in bold text in

Table 6-2 in order to highlight which naturally occurring metals may be present in concentrations triggering further investigation. The bold and underlined cut-off value for lead is greater than the modified HIL criteria, suggesting that naturally elevated lead concentrations in site soils may present health risks. Based on these comparisons, the manner of assessing health risks posed by lead in soil (discussed further in GHD, 2019) and the representativeness of the CSA Global Cut-Off Value as a 'background' concentration for soils of the site may require further assessment to validate that the site can be safely used for the predicted end uses. Additionally, exposure pathways for lead during the Stage 3 rehabilitation works are likely to require control to protect worker safety.

With the exception of lead, the development of modified HIL-C and HIL-D criteria specific to end land use scenarios provides an indication that the drivers for surface soil remediation onsite (beyond those relating to EBFR water quality improvement) are likely to be governed by risks to ecological receptors and eco-toxicity risks posed to landform revegetation and rehabilitation success rather than by future human exposure scenarios.

It should be noted that due to the mineralised nature of regional soils, the direct application of nationally recognised Ecological Investigation Levels (EILs) in the assessment of site soil quality is not recommended. Instead, revegetation strategies of the project should identify local plant species that may have adapted to these regionally specific conditions, as well as practicable means of shallow soil amelioration throughout cover systems installed in the rehabilitation works and across the Old Tailings Dam area. This may include an updated soil pH survey across the area prior to commencement of work to validate the current assumption that the revegetation process is being hindered by physical processes (*e.g.* fire and compaction) rather than chemical processes.

Study Comparing the Old Tailings Dam and Copper Extraction Pad Areas

Comparatively, based on the most comprehensive data set for shallow soils across both areas (CSA Global, 2011; see Appendix), shallow soils at the Copper Extraction Pad are shown to statistically contain greater total metal concentrations than soils of the Old Tailings Dam, with the exception of chromium. Figure 6-9 displays the CSA Global (2011) XRF data noting that outliers are removed from the box-and-whisker plots presented below. The differences in heavy metal loads in subsoils of each area are intuitively proportionate to the types of operational practices performed in the two areas, with one receiving tailings drainage products and the other receiving drainage from aggressive heap-leaching processes.

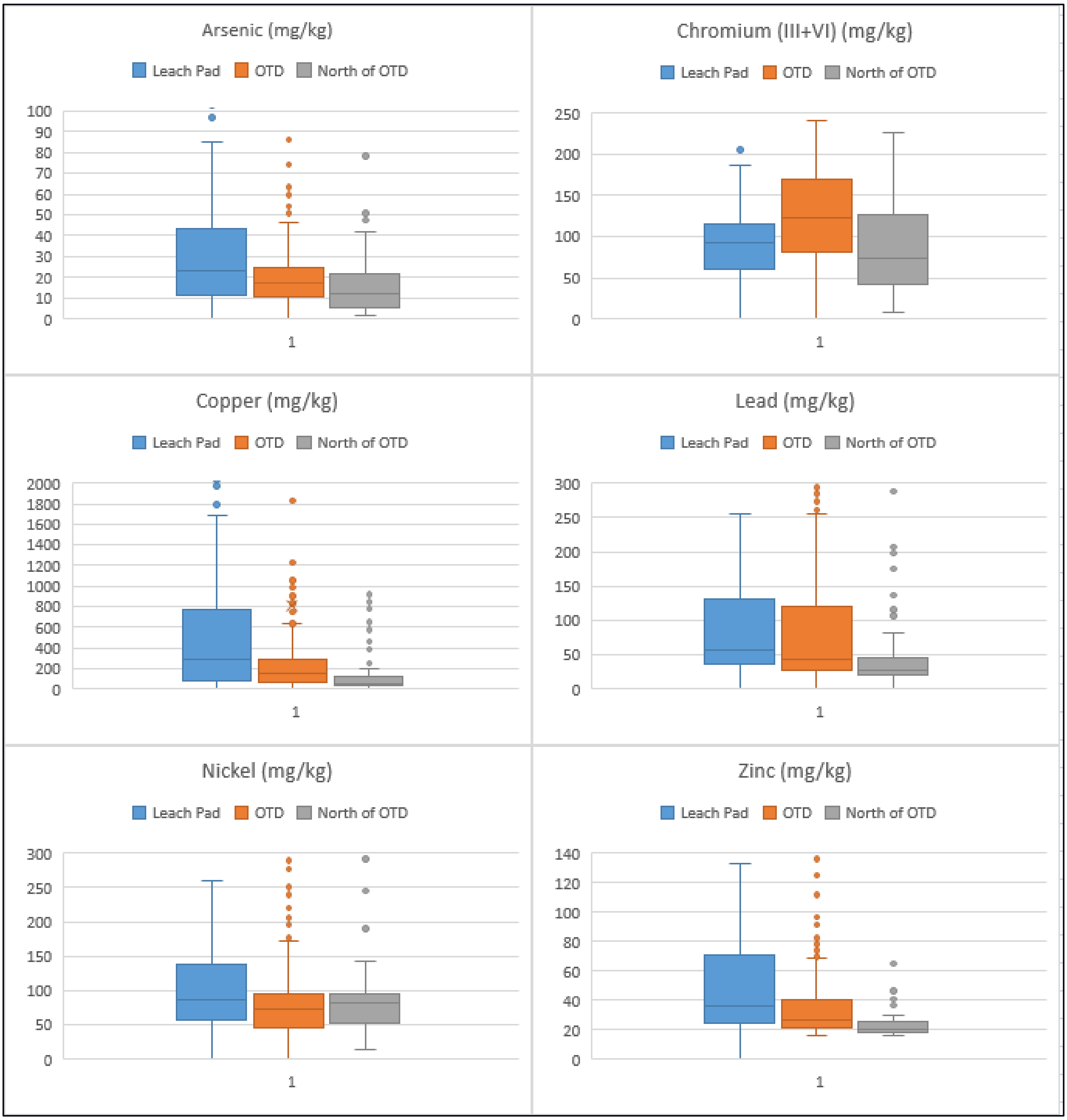



Figure 6-9: Comparative heavy metal total concentrations within shallow soils of the Copper Extraction Pad (n=193), Old Tailings Dam (n=492) and undisturbed areas north of the Old Tailings Dam (n=85)

*Data from DPIR database and generated in XRF surveys by CSA Global Consultants in 2010/11*

Figure 6-10 displays copper concentrations measured in the subsoil profile of the Old Tailings Dam area and includes data collected during (or immediately following) the removal of tailings from the area in 1984 (Lowson *et al.*, 1987), as well as CSAG data for the area from 2010/11.

The CSA Global data for the shallow cover soil horizon (green) is limited, but shows considerable (and lasting) improved soil quality in near surface soils. The data also demonstrates the effectiveness of the decision to remove the upper 200 mm of subsoil (black crosses) in the 1984 rehabilitation works.

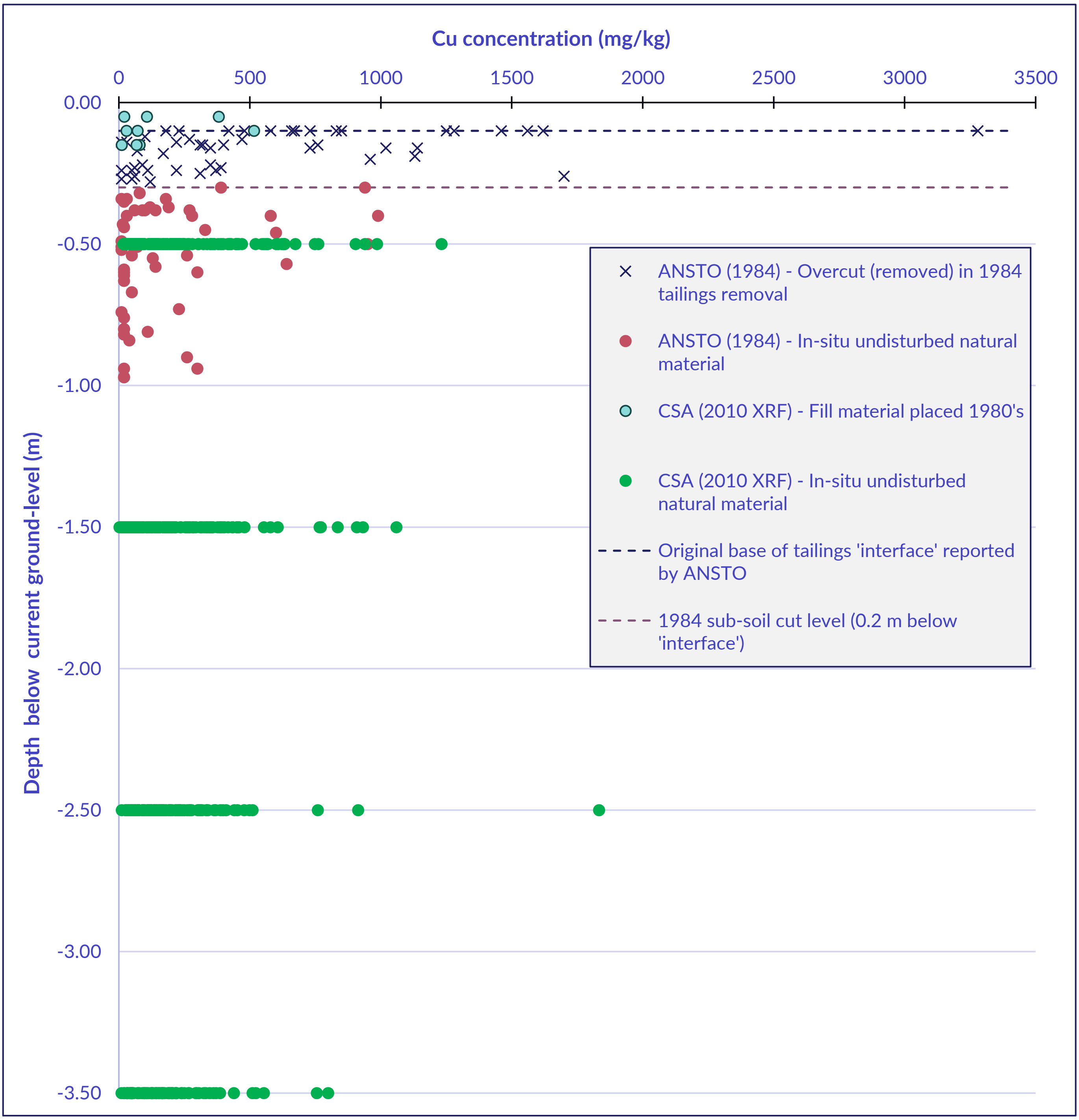



Figure 6-10: Copper concentrations in the subsoil profile of the Old Tailings Dam area and the lasting effect of the 1984 rehabilitation works

Due to comparative differences in shallow metal concentrations at the Copper Extraction Pad and the Old Tailings Dam area; the proximity of the Copper Extraction Pad to the former EBFR watercourse (which is to be reinstated) and the presence of considerable acid and metalliferous impacts in groundwater beneath the Copper Extraction Pad, a remedial earthworks and vegetation plan has been established for the former Copper Extraction Pad area for disposal to the WSF. The purpose of this Excavation Plan is not to remove all copper contaminated soil from its present location but to remove a suitable depth of material to establish a backfilled clean fill depth suitable for establishing vegetation and providing a barrier between the contaminated soils and human or ecological receptors.

An assessment of groundwater conditions within the Old Tailings Dam indicates that the relatively shallow groundwater (see Chapter 10 - Inland Water Environmental Quality) is moderately impacted by sulphate, however metals concentrations remain low and pH fluctuates from 7.7 to 5.3 across the site and over seasons. There is an adjacent plume of AMD-impacted groundwater at the old stockpile area (east of the Old Tailings Dam) that may be contributing to fluctuating lower pH values at one location on the Dam footprint. The majority of sites across the Old Tailings Dam footprint report near-neutral pH. This is discussed further in Chapter 10 – Inland Water Environmental Quality.

In order to understand the core reasons for poor revegetation recover at the Old Tailings Dam, the area will undergo soil testing and amelioration trials (lime amendment, soil structure improvement, composting and introduction of new inoculating soils) and physical improvements (fire protection and ripping) before being used for revegetation systems establishment and trials, and plant nursery operations prior to earthworks for the benefit of site-wide revegetation. The area is proposed to be used for future cycad relocation from newly disturbed footprints (such as the new WSF).

***Radiological hazards - Soils***

Radiological risks to Construction phase workers and potential future land users are posed by several sources onsite. The identification and evaluation of risks posed by 'radiological soils' is somewhat confounded by the presence of naturally elevated background concentrations of uranium in local soils borne from the highly mineralised underlying parent geology of the Rum Jungle Complex. However, unacceptable soil radionuclide conditions exist in several areas as discussed in Chapter 16 - Radiation and the *Rum Jungle Radiological Hazard Assessment Report* (EcOz, 2019b – see Appendix). Typically these 'hot spots' correlate to areas of higher gamma emissions, elevated radon in air, radon emanations and $^{226}$Ra activity and an example map is shown here in Figure 6-11. These 'hot spots' require remediation in order to achieve the overall project objectives.

The Excavation Plan for the Construction phase has been developed primarily to address onsite radiological soil hazards which includes soils of the southwest face of the ridgeline located east of Main Pit and at specific 'hotspots' across the site as shown in Figure 6-11. Further details of the Remediation Plan for radiological soils are examined in Chapter 7 – Rehabilitation Strategy of this EIS.

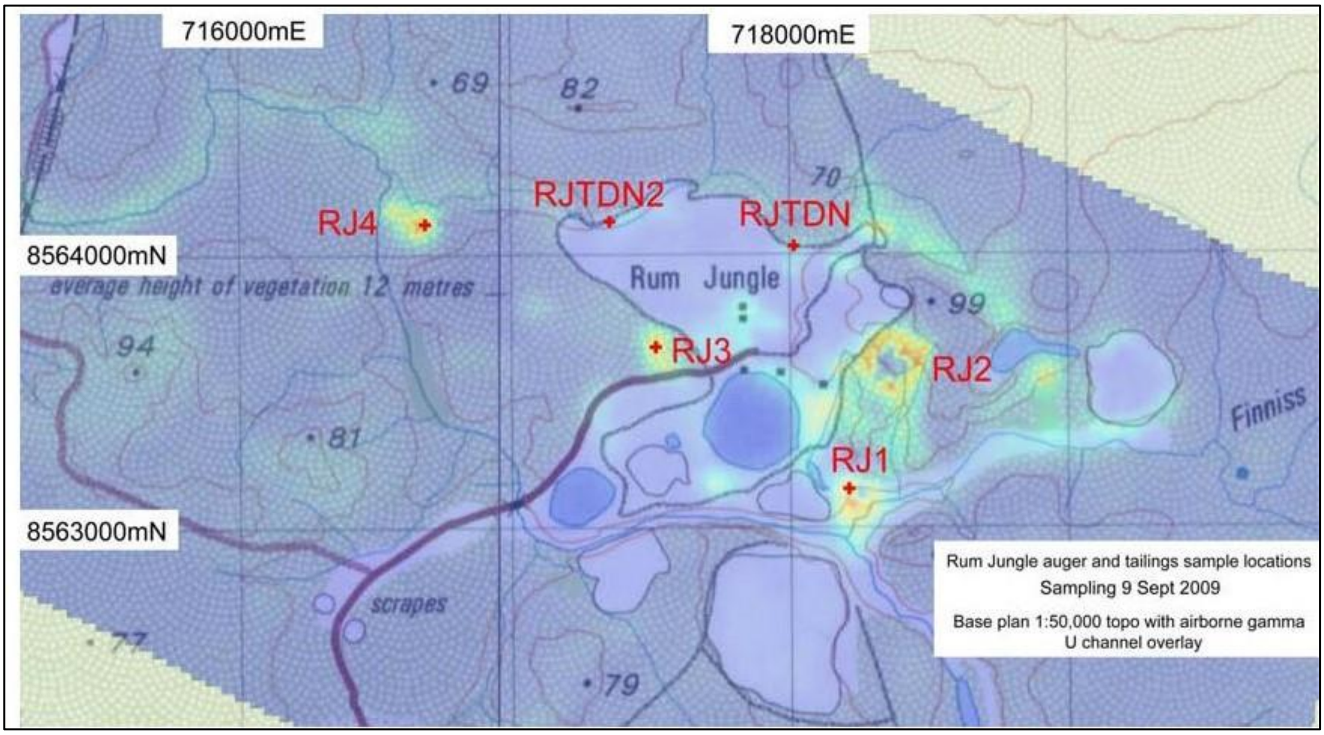



Figure 6-11: Radiological anomalies at Rum Jungle site investigated by Hughes and Bollhöfer (2010)

*Plot of 2006 airborne gamma survey overlaying topographic map (1:50,000) with plotted auger sampling points in the RJ and RJTD series*

### *Radiological Hazards - Uranium in Surface Water*

A review of the extensive water quality monitoring data set for Rum Jungle reveals seasonal pulses of uranium concentrations in surface water throughout the EBFR. Generally, the uranium concentrations are below the LDWQO as set by Hydrobiology (2019). Several example data sets are presented here in order from farthest upstream (Zone 1) to downstream (Zone 7) and presented by Zones as described by Hydrobiology (2019) (and mapped in Figure 6-12). The data for each sample point is plotted against the LDWQO for each Zone. These values are presented in Table 6-3 and Figure 6-13.

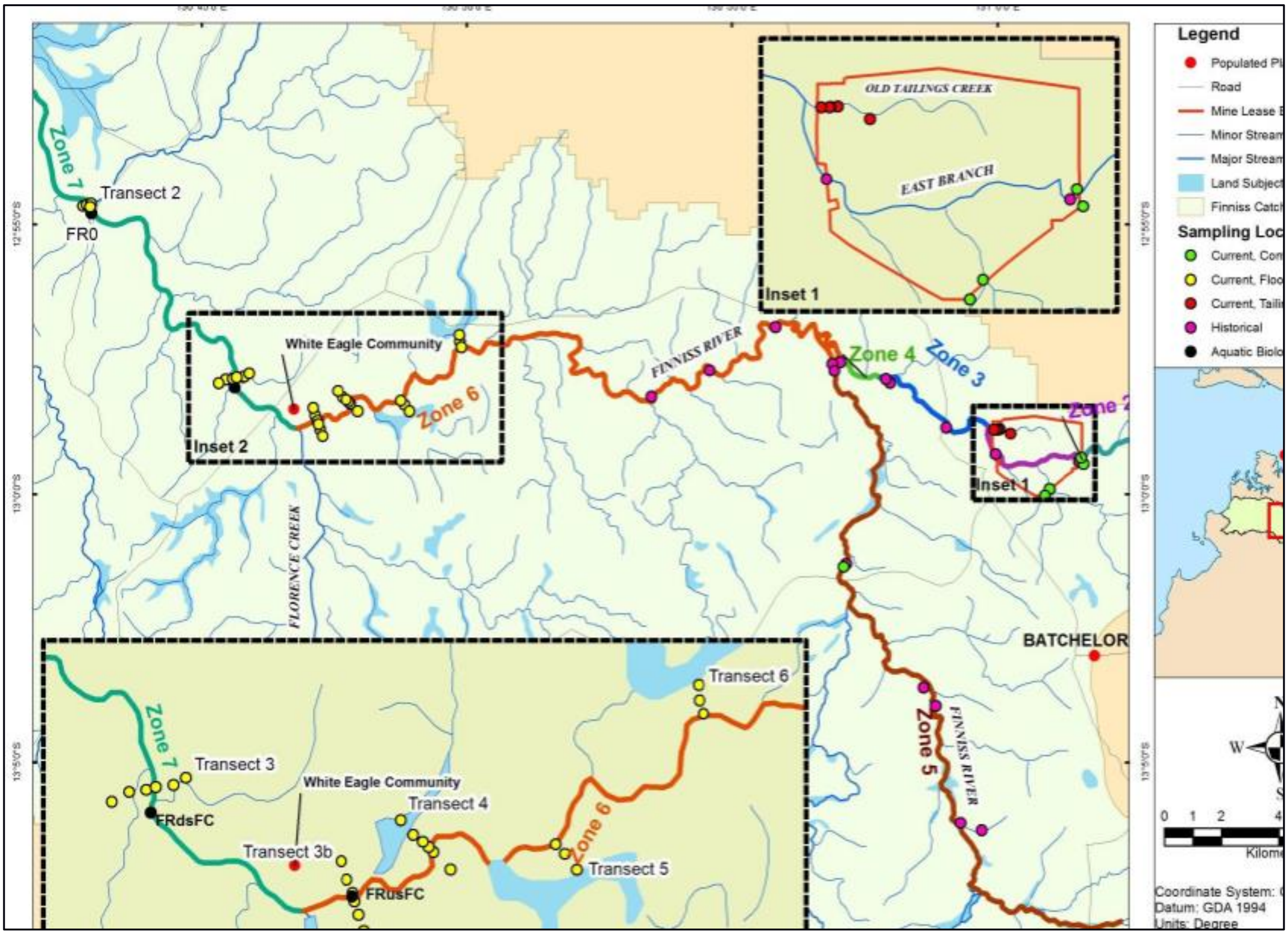
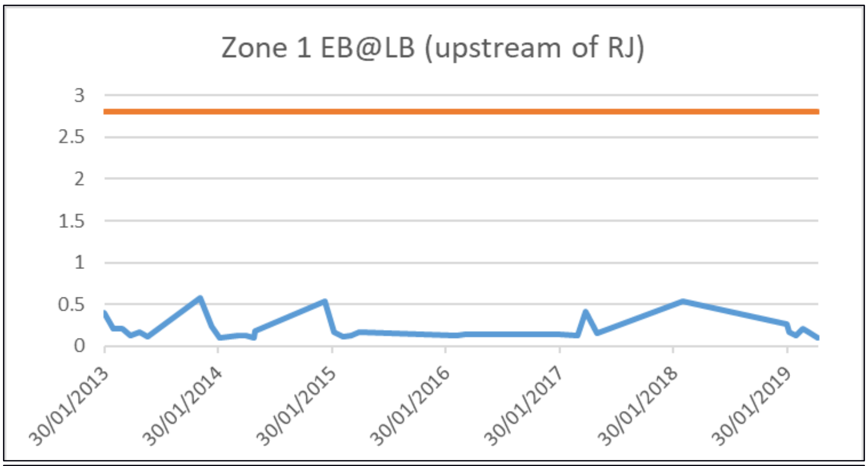
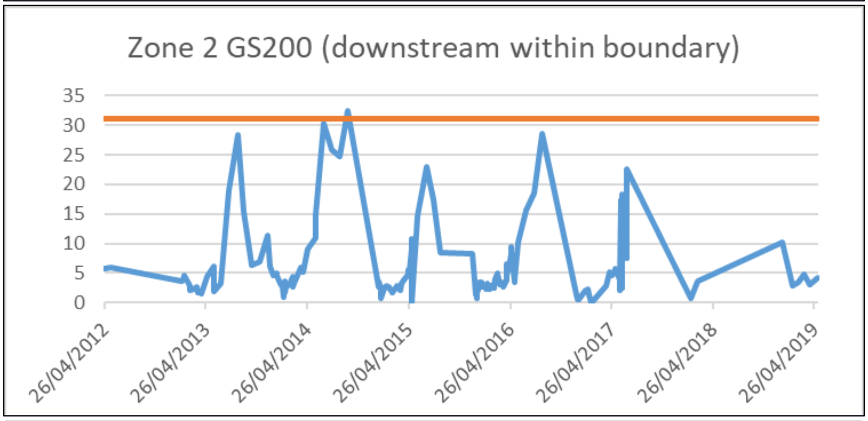


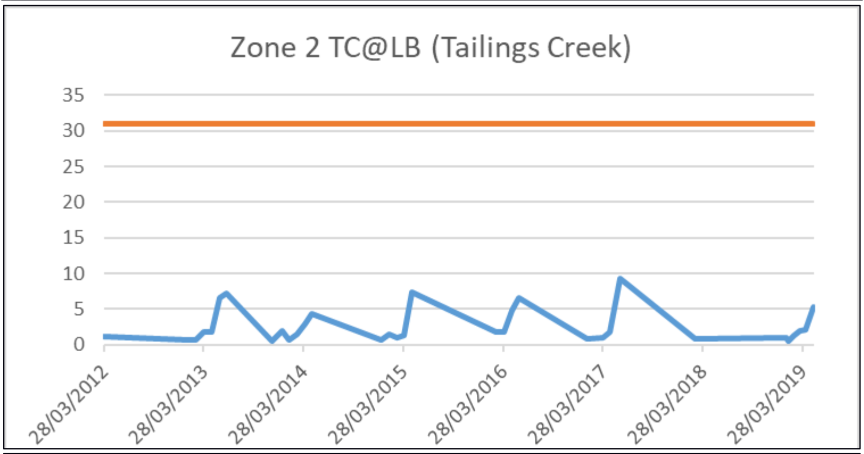

Figure 6-12: Finniss River zones as developed by Hydrobiology (2019)

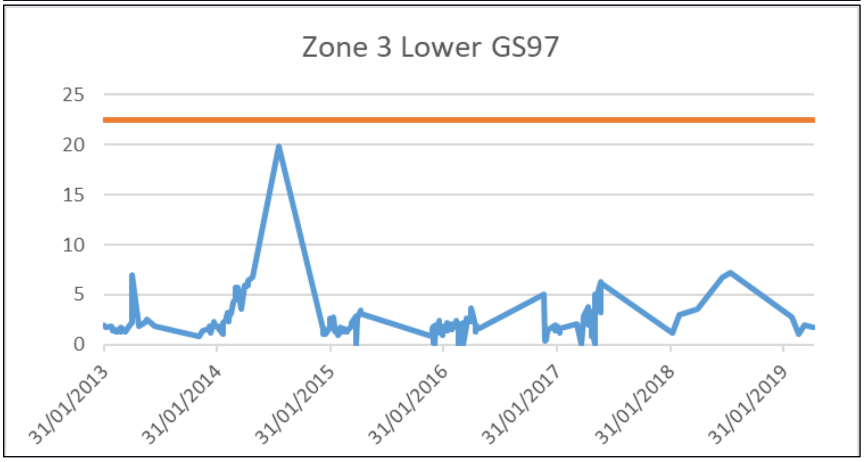
Table 6-3: LDWQO for Uranium (U) by zone (Hydrobiology, 2019)

| Zone | Interim U LDWQO (μg/L) |
|---|---|
| Zone 1 | 2.8 |
| Zone 2 | 31 |
| Zone 3 | 22.5 |
| Zone 4 | 13.2 |
| Zone 5 | 2.7 |
| Zone 6 | 2.9 |
| Zone 7 | 2.7 |


Zone 1 EB@LB (upstream of RJ)
3
2.5
2
1.5
1
0.5
0
30/01/2013
30/01/2014
30/01/2015
30/01/2016
30/01/2017
30/01/2018
30/01/2019


Zone 2 GS200 (downstream within boundary)
35
30
25
20
15
10
5
0
26/04/2012
26/04/2013
26/04/2014
26/04/2015
26/04/2016
26/04/2017
26/04/2018
26/04/2019


Zone 2 TC@LB (Tailings Creek)
35
30
25
20
15
10
5
0
28/03/2012
28/03/2013
28/03/2014
28/03/2015
28/03/2016
28/03/2017
28/03/2018
28/03/2019


Zone 3 Lower GS97
25
20
15
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5
0
31/01/2013
31/01/2014
31/01/2015
31/01/2016
31/01/2017
31/01/2018
31/01/2019

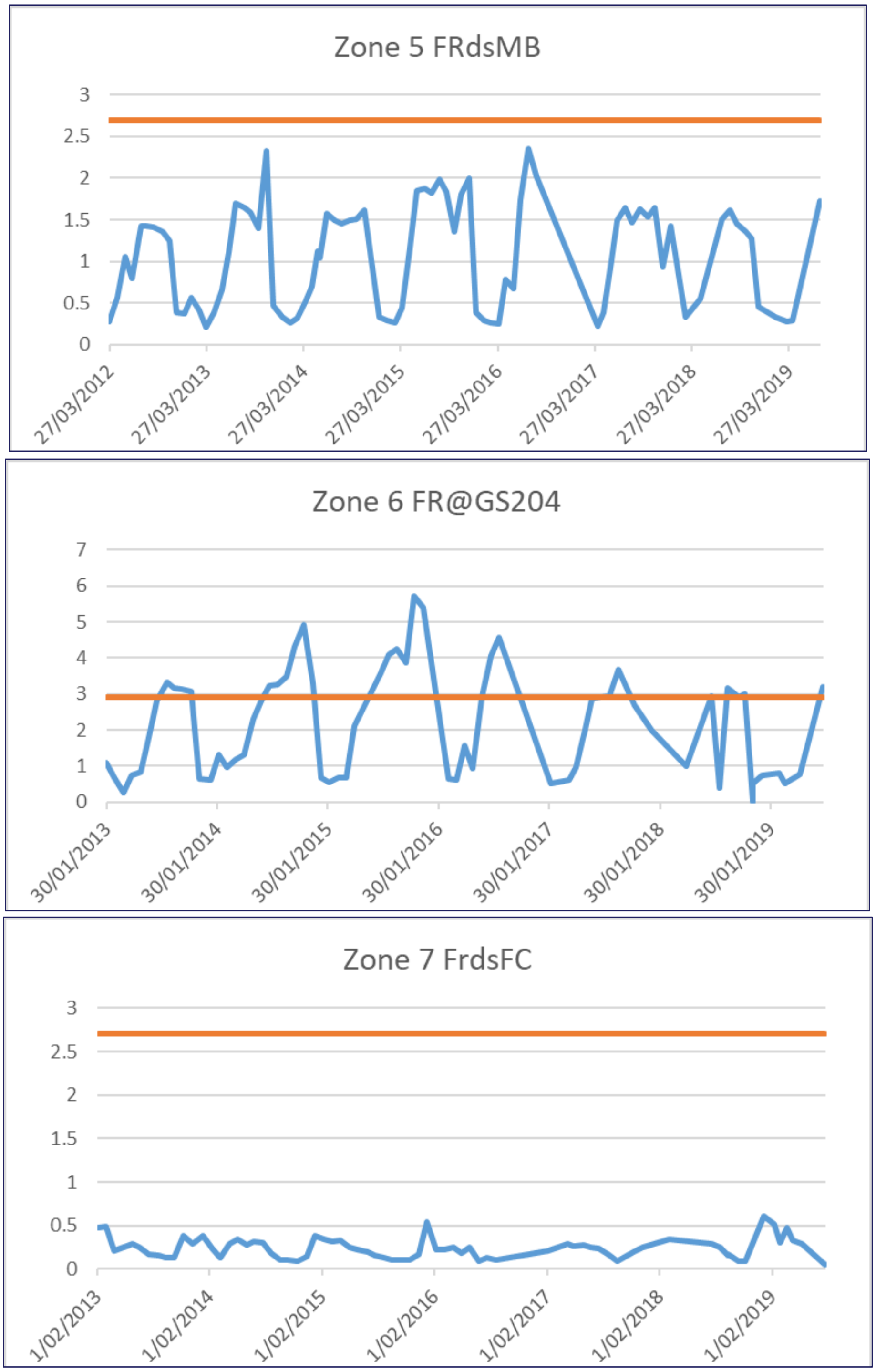


Figure 6-13: Uranium (U) concentrations (Blue) along the EBFR compared to LDWQO (Orange)

This data set shows exceedance of the LDWQO at Zone 2 gauge GS8150200 onsite and at Zone 6 gauge GS8150204. The Zone 6 gauge GS150204 concentrations are counter-intuitive in that this site is well downstream of Rum Jungle and the values obtained at this point are higher on average than the Zone 5 FRdsMB site upstream. It would be expected that through further catchment dilution further downstream that Zone 6 values would be lower than Zone 5 values. The results are contrary to this logic and may indicate that there are other catchment wide uranium sources or an evapo-concentration cycle is taking place.

Additionally, the Australian Drinking Water Guideline value for uranium is 17µg/L (NHMRC, 2011) of which this value is breached seasonally onsite (Zone 2 gauge GS8150200). There is a singular exceedance of this value at gauge GS8150097 which appears anomalous to the remaining data set for that site. All other results are below this guideline value.

Onsite sources of soluble uranium to surface water are likely to be surface water runoff from areas onsite impacted by radiological soils, particularly the old ore stockpile area north of Main Pit and upstream of the Main Pit which is the historic Acid Dam area within the EBFR. Additionally, groundwater monitoring data from site indicates that Dyson's WRD and Main WRD are contributing uranium load to shallow groundwater and, as discussed in Chapter 11 – Inland Water Environmental Quality, this reports to surface waters onsite.

### *Salt affected soils*

White sulphate salts precipitate throughout the Dry season and provide a clear indication of where the surface expression of seepage occurs from all WRDs. The most obvious areas of impact include the seepage zone on the northern face of Intermediate WRD (which extends into the diversion channel), much of the perimeter toe drain around Main WRD, the former 'Sweetwater Dam' area (located near the confluence of Fitch Creek and the EBFR) and seepage expressions in drainage channels on the southern faces of Dyson's (backfilled) Pit and Dyson's WRD. These salt affected areas and ephemeral water channel reaches are a contributor to 'first flush' impact events to the EBFR at the commencement of each Wet season. Examples of salt affected soils can be seen in Figure 6-14.

Figure 6-14: Sulphate efflorescence at various locations on the Rum Jungle Mine site

### ***Asbestos Containing Materials (ACMs)***

Limited amounts of ACM remain onsite, associated with buildings and relic mining equipment and machinery. These are mainly located in the former plant and workshop areas north of Main Pit, but also include remote and isolated equipment, such as an old drilling rig and davit equipment (east of Main Pit) and pumping/piping materials (eastern end Old Tailings Dam).

Asbestos warning stickers are placed on several of the buildings onsite. As one or more of the three existing workshop sheds may be used during the rehabilitation works (to store imported lime or to be re-furnished as plant/equipment workshops), updated asbestos surveys will be required prior to their use followed by ACM removal where required.

As with radiological soils, the rehabilitation works program will include the identification and removal of ACM bearing equipment and building materials from active work areas in initial site establishment phases. These will eventually be disposed to a nominated location or ‘cell’ within the WSF, but may need to be temporarily aggregated and suitably covered to allow for initial WSF construction activities. ACM will be identified and removed by suitably experienced and licensed asbestos specialists. This early project action is expected to mitigate the potential for ongoing worker exposure to asbestos risks during the remainder of the site rehabilitation works and will negate ACM risks onsite permanently.

An active Asbestos Register (has) and will be maintained throughout the duration of the project, to keep a continuous record of suspected ACMs and to action identification and management protocols, akin to an ‘unexpected finds protocol’.

There is a low likelihood of asbestos free fibres within the surface soils around the existing buildings as this area was backfilled in 1977 using the material from the lead ore stockpile and then reshaped, lime treated and revegetated in the 1984-1985 secondary rehabilitation period (Allen and Verhoeven, 1986). However, this area will be utilised for the construction of new temporary facilities for Stage 3 in the event that no agreement can be reached with Browns Oxide Mine for the lease of existing facilities. The area is to be sheeted with coarse, free draining material to limit exposure to potential contaminants in this area.


Figure 6-15: Examples of Asbestos Containing Materials (ACMs) on the former Rum Jungle Mine site

***General Wastes***

Across site there are several locations where scrap metal and glass wastes have been disposed historically into bushland. These materials do not appear to be causing chemical impact to the surrounding environment but are causing an impact to visual amenity, land use and potentially to worker safety in the future. These scrap products are planned for clean-up prior to commencement of rehabilitation earthworks and will be disposed of offsite as *per* Council requirements.

### 6.3.5. Summary of Conceptual Site Model

The following table is the generalised Conceptual Site Model summarising the contamination sources, pathways and receptors as described above and in subsequent Chapters of this EIS. Further detail is available in the relevant Chapters of this EIS as listed here:

- Surface and Groundwater Vectors and Receptors see Chapter 10 – Inland Water Environmental Quality and Chapter 11 – Hydrological Processes.
- Ecological Vectors and Receptors see Chapter 12 – Aquatic Ecosystems and Chapter 14 – Terrestrial Flora and Fauna.
- Radiation Vectors and Receptors see Chapter 16 - Radiation.
- Human Health Vectors and Receptors see Chapter 15 – Human Health and Safety.

The remediation processes for Rum Jungle are described in the following Chapter 7 – Rehabilitation Strategy.

Table 6-4: Tabulated Conceptual Site Model (Generalised)

| Source Details | | Pathway Details | Receptor Details |
|---|---|---|---|
| Legacy WRDs and Operational Features (primary contamination sources) | *Tailings and Waste Rock Dumps*<br>Intermediate WRD - predominantly PAF-I<br>Main WRD - full range of PAF and NAF<br>Dyson’s (backfilled) Pit - shallow backfill predominantly PAF-I<br>Dyson’s WRD - predominantly NAF<br>Main North WRD - contaminated spoil (NAF)<br><br>*Rehabilitated Former Operational Areas*<br>Copper Extraction Area - copper and sulphate<br>Former Plant Site - radiological soils and asbestos containing legacy structures<br>Old Tailings Dam Area - leached metal impacts in subsoils<br>Old Stockpile Areas - radiological soils and isolated pocket of process liquor (in sub-surface) | *Contamination Vectors from Waste Rock and Contaminated Soils*<br>Atmospheric exchange due to cover-system absence or deterioration leading to increased acidification, sulphate and heavy metal release *via* seepage and/or leaching to groundwater.<br>Capillary rise of contaminants through cover systems to surface soils.<br>Seepage of impacts from landforms caused by infiltration and formation of elevated hydraulic pressure within mounded features.<br>Salt affected soils and drainage channel / watercourse sediments (secondary source). | Surface water body and sediments (ultimately EBFR)<br>Groundwater aquifer (and secondary source) |
| | | *Surface Water and Groundwater Vectors*<br>Lateral migration of impacted soils through fluvial and aeolian dispersion.<br>Lateral migration of exposed residual contamination *via* surface water flow.<br>Vertical or lateral seepage of contamination within groundwater. | |
| | | *Radiation Vectors*<br>Release of radon and radiation associated with radiological sources. | Atmospheric and dispersion |
| | | *Ecological Vectors*<br>Direct contact between terrestrial fauna and surface contaminants (sub-surface contaminants with burrowing fauna).<br>Bioaccumulation in terrestrial and aquatic flora and fauna. | Terrestrial flora and fauna (within riparian zone)<br>Aquatic flora and fauna (within nearby surface water bodies) |
| | | *Human Health Vectors*<br>Ingestion of contaminated media *via* consumption of impacted flora, fauna, surface water and groundwater.<br>Direct contact with contaminated soils, sediment, surface water and groundwater. | Traditional land owners / users<br>Site workers<br>Other site visitors |
| Surface/Ground Water Features (acting as secondary sources and pathways) | *Impacted Groundwater*<br>AMD-impacted groundwater<br>Cu liquor impacted groundwater<br><br>*Legacy Mine Pits – Surface Waters*<br>Intermediate Pit<br>Main Pit<br><br>*Surface Water Channels (and sediments)*<br>East Finniss Diversion Channel<br>Upper EBFR (incorporating former Acid Dam)<br>Fitch Creek (incorporating former Sweetwater Dam)<br>Former EBFR Channel (now incorporating Copper Creek) | *Surface Water and Sediment Vectors*<br>Dispersion / migration of contaminants in surface water and sediments.<br>Short term sinks for contaminated sediments.<br>Concentration / settling of contaminants in slow moving or stagnant waters during dry seasons. | Surface water body and sediments |
| | | *Groundwater-Surface Water Interaction (seasonally ephemeral)*<br>Lateral seepage from groundwater to river in wet seasons.<br>Vertical or lateral seepage from river to groundwater in dry seasons. | Groundwater aquifer |
| | | *Ecological Vectors*<br>Impacts to riparian zones from contaminated surface water, groundwater, sediment or WRD seepage.<br>Bioaccumulation in aquatic flora and fauna. | Terrestrial flora and fauna (within riparian zone)<br>Aquatic flora and fauna (within surface water body) |
| | | *Human Health Vectors*<br>Ingestion of (drinking) or direct contact with (bathing, recreational use) surface water.<br>Ingestion of contaminated media *via* consumption of impacted flora, fauna, surface water and/or groundwater. | Traditional land owners / users<br>Site workers<br>Other site visitors |

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# 7. Rehabilitation Strategy

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## 7.1. Overview

The Rum Jungle Mine operated between 1953 and 1971 and produced 3,530 t of uranium oxide and 20,000 t of copper concentrate, as well as some nickel and lead products. The former mining and processing operations resulted in legacy landforms, groundwater and surface water contamination, including significant AMD issues and impact to the EBFR. The site and downstream environs have been the subject of numerous phases of investigation, remediation and rehabilitation since the late 1970s, with the most significant rehabilitation works implemented between 1983 and 1986.

The previous Chapter 6 – Existing Site Condition describes the current site conditions from a values' perspective. This includes a discussion on the historic and more recent contamination processes and impacted cultural values related to landscape. Following from this assessment of site conditions and compromised values, a Rehabilitation Strategy is presented in this chapter. The Rehabilitation Strategy includes actions targeting the remediation of existing AMD contamination sources and the interruption of other contaminant source-pathway-receptor linkages. The Rehabilitation Strategy addresses, as far as achievable, the physical aspects of the site that require remediation – namely the flow path of the EBFR and the quality of fluvial landscapes. Finally, the chapter concludes with the proposed revegetation strategy that is critical in terms of site stability and ecological and spiritual performance. These actions are designed to deliver on land and water quality that supports the future Land Use Plan which is described below.

In the contaminated land framework, this chapter, and the EIS as a whole, presents a key component of a Remediation Action Plan in line with project objectives described in Chapter 1 - Introduction.

A high level summary of the Rehabilitation Strategy elements is shown here:

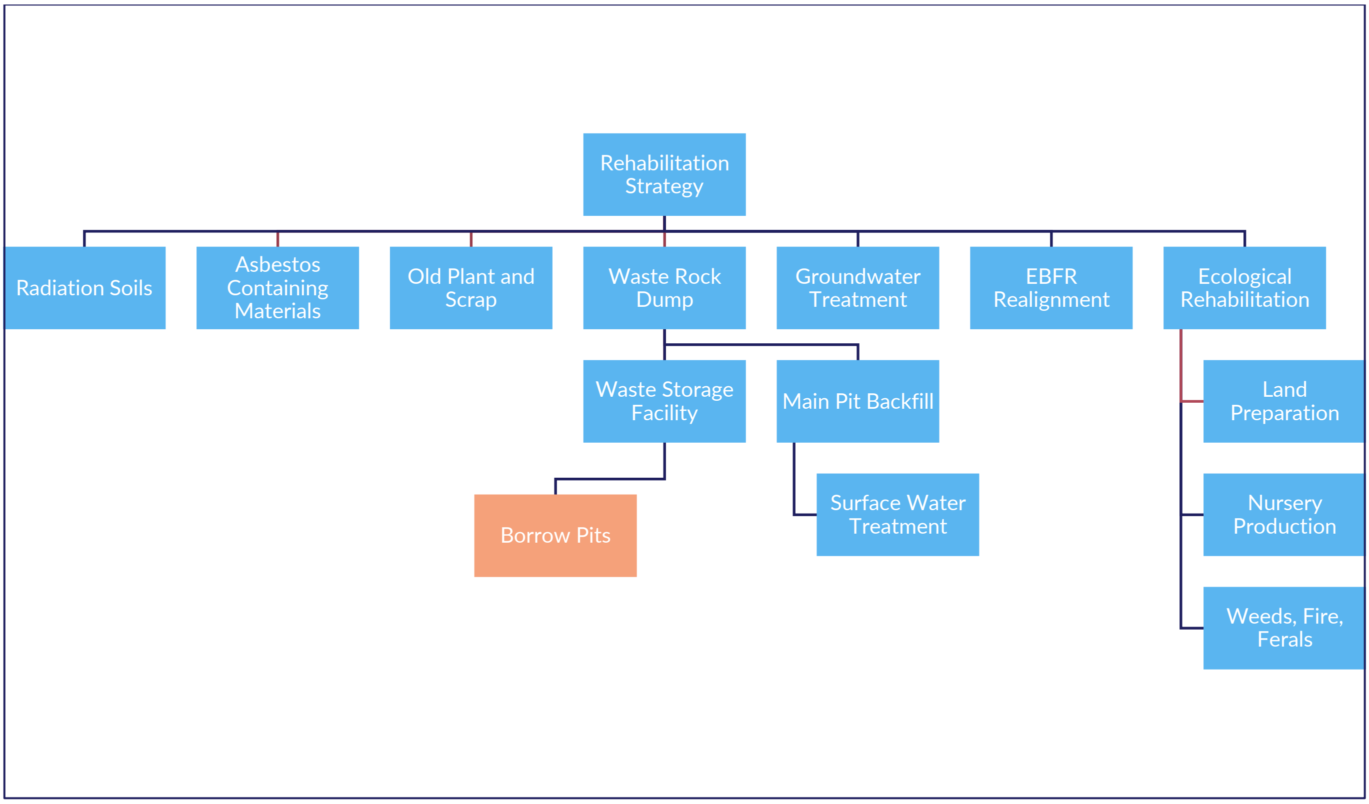


Figure 7-1: Rehabilitation strategy summary

## 7.2. Future Land Use

A Land Use Plan has recently been developed by a panel of Traditional Owners, the Proponent and Australian Government officers. This panel discussed traditional views of the Rum Jungle site and developed a vision of the future that was cognisant of potential limitations due to current land and water conditions that will be rehabilitated to the extent that is reasonably possible and require future management. Traditional Owners expressed a range of views and beliefs about the importance of this land ranging from a view held by some that this land is associated with 'sickness country' through to strong connections to sacred sites. This Plan is shown in Figure 7-2. The future land uses proposed are conservation of new landforms to protect structural integrity, access to site for cultural practices, and potentially to utilise the cultural centre as a base for future land management activities across the FRALT. Other future land uses proposed include access to onsite and nearby country to teach younger generations bush skills and culture, practicing caring for country and potential cultural tourism ventures combining access to the cultural centre and bushwalks in undisturbed country. It is important to view this Plan through a lens of connected country where the current project boundary may not exist in future if the land claim is resolved. Already the undisturbed portions of land onsite connect to undisturbed FRALT land surrounding the Rum Jungle site.

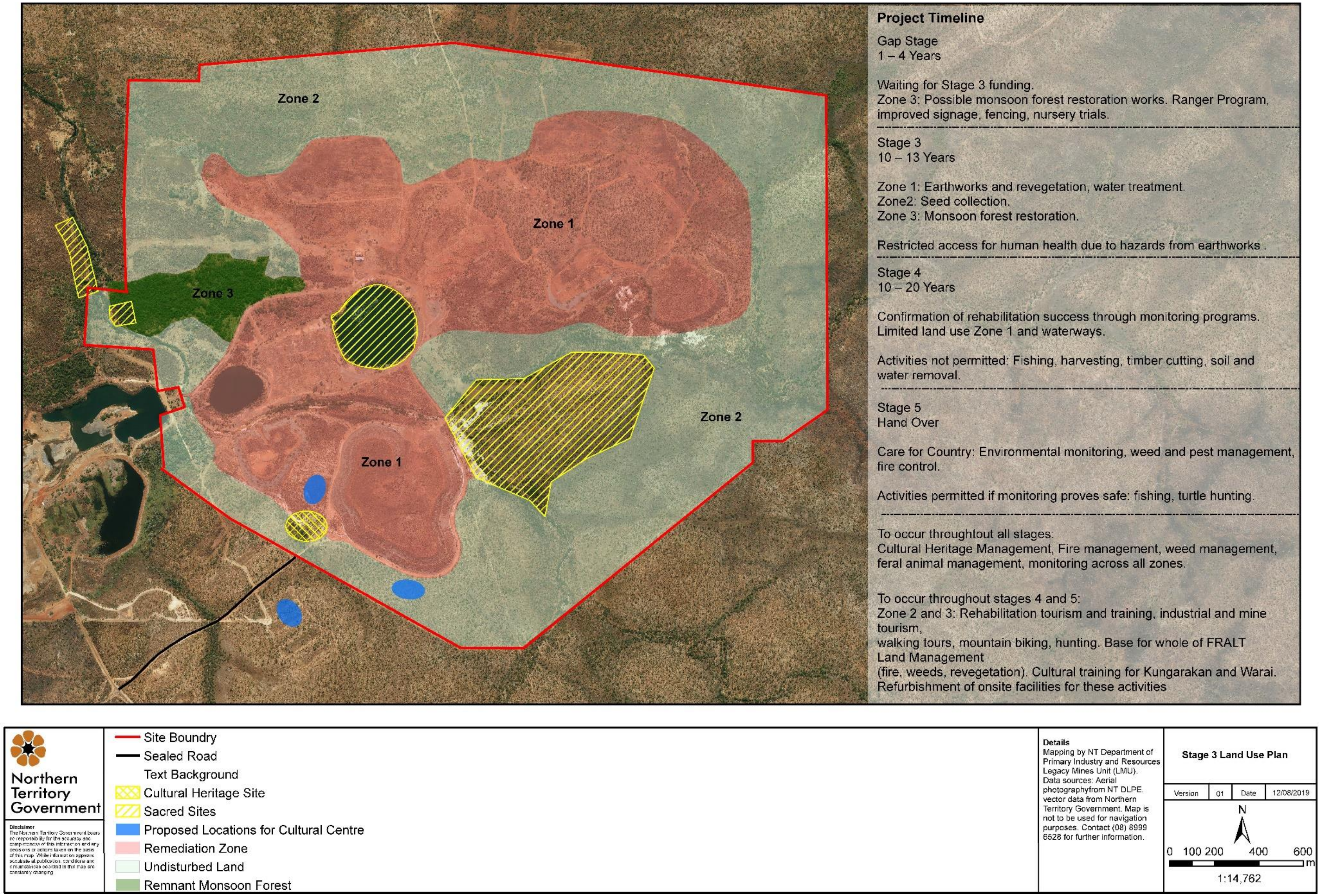


Figure 7-2: Land Use Plan

## 7.3. Remediation Action Plan

Contaminated site management strategies should protect all segments of the physical environment (air, land and water, including groundwater) and environmental values, including ecological and human functions supported by the environment. The development of remediation strategies must also consider existing and future public and occupational health and safety risks and benefits.

The fundamental goal of remediation should be to render a site acceptable and safe for the long-term continuation of its proposed use and to maximise (to the extent practicable) its potential future uses.

Hierarchies for site clean-up and management are as follows, and several of these strategies are to be employed through the project:

i) Onsite treatment of soil (or water) so that the contaminant is either destroyed or the associated hazard is reduced to an acceptable level

ii) Off-site treatment of soil (or water) so that the contaminant is either destroyed or the associated hazard is reduced to an acceptable level, after which it is returned to the site.

If it is not possible to remove or destroy contaminants to levels that permit the retention or return of treated media to its site of origin, further options may include:

i) Removal of contaminated soil (or water) to an approved site or facility followed by (where necessary) replacement with clean fill

ii) Isolation of the contamination onsite, for example in appropriately designed and managed containment facilities

iii) Land use controls and management such that less sensitive land uses mitigate the need for remedial works (that may include partial remediation)

iv) Leaving contaminated material *in situ* providing there is no immediate danger to the environment or community and the site has appropriate management controls in place.

With this contaminated land framework as a guide, the scope of works for the Stage 3 Rehabilitation Project was developed. The restoration works form an essential component of the Stage 3 scope of works and this chapter describes the actions planned to address the compromised environmental and cultural values resulting from the contaminating processes. In summary, the actions planned to address contamination processes are:

- Slow down or halt the AMD production reactions from waste rock onsite.
- Treat existing groundwater sources (*i.e.* the Main and Intermediate WRDs) that contaminate the EBFR.
- Treat other AMD-impacted groundwater sources that do not contribute to the EBFR copper load (old ore stockpile area).
- Isolate radiological and AMD affected soils at the Rum Jungle site and Mt Burton from environmental and human receptors.
- Isolate asbestos materials at the Rum Jungle site from environmental and human receptors.
- Slow down or halt the future generation and transportation mechanisms for copper and other metals in the new WSF.

The actions that are planned to address the compromised environmental and cultural values that are not related to contamination processes are:

- Return the EBFR to its original course as far as possible.
- Restore land parcels that are poorly vegetated such as the Old Tailings Dam area and vine thicket stand.
- Revegetate new landforms to stabilise the surface and restore ecological function as far as practicable.

The following sections describe the deconstruction, decontamination and isolation processes that are planned to take place at the existing contaminant sources. This is then followed by a description and discussion of the methodology for construction of new facilities – including methods to attenuate and retain contaminants onsite. The contaminants at Rum Jungle are not amenable to bioremediation, destruction or transformation remedial methods.

## 7.4. Waste Rock Management

Waste rock from former mining activities at the Rum Jungle site is currently stored on surface in three locations – the Main, Intermediate and Dyson's WRDs – which are shown in Figure 7-3. These facilities are the primary sources of AMD onsite and are also to be managed as a radiological source due to the fact they contain naturally-occurring low grade uranium. The presence of low grade uranium is significant as it presents a potential radiological hazard to Stage 3 workers. This is addressed in Chapter 16 – Radiation. For the purposes of discussing the primary Contaminant of Concern, the Main and Intermediate WRDs are the most significant contributors to copper loads reporting to the EBFR *via* groundwater and subsurface seepage flows (interflow). For further detail, the reader is directed to Chapter 6 – Existing Site Condition, Chapter 10 – Inland Water Environmental Quality and the *Rum Jungle Minesite Physical and Geochemical Characteristics of Waste Rock and Contaminated Materials* (RGC and Jones, 2019 – see Appendix).

Groundwater within the Main and Intermediate Pits' reach is a secondary source of copper contamination to the EBFR and, as such, a Seepage Interception System (SIS) is planned for this area. The purpose of the SIS is to capture existing AMD-impacted groundwater and interflow, and direct these to the WTP. This system is planned to operate for the full period of Stage 3 works and is expected to recover the majority of stored copper within the saturated and unsaturated zones. This is discussed in detail, including the modelling approach, in Chapter 10 – Inland Water Environmental Quality.

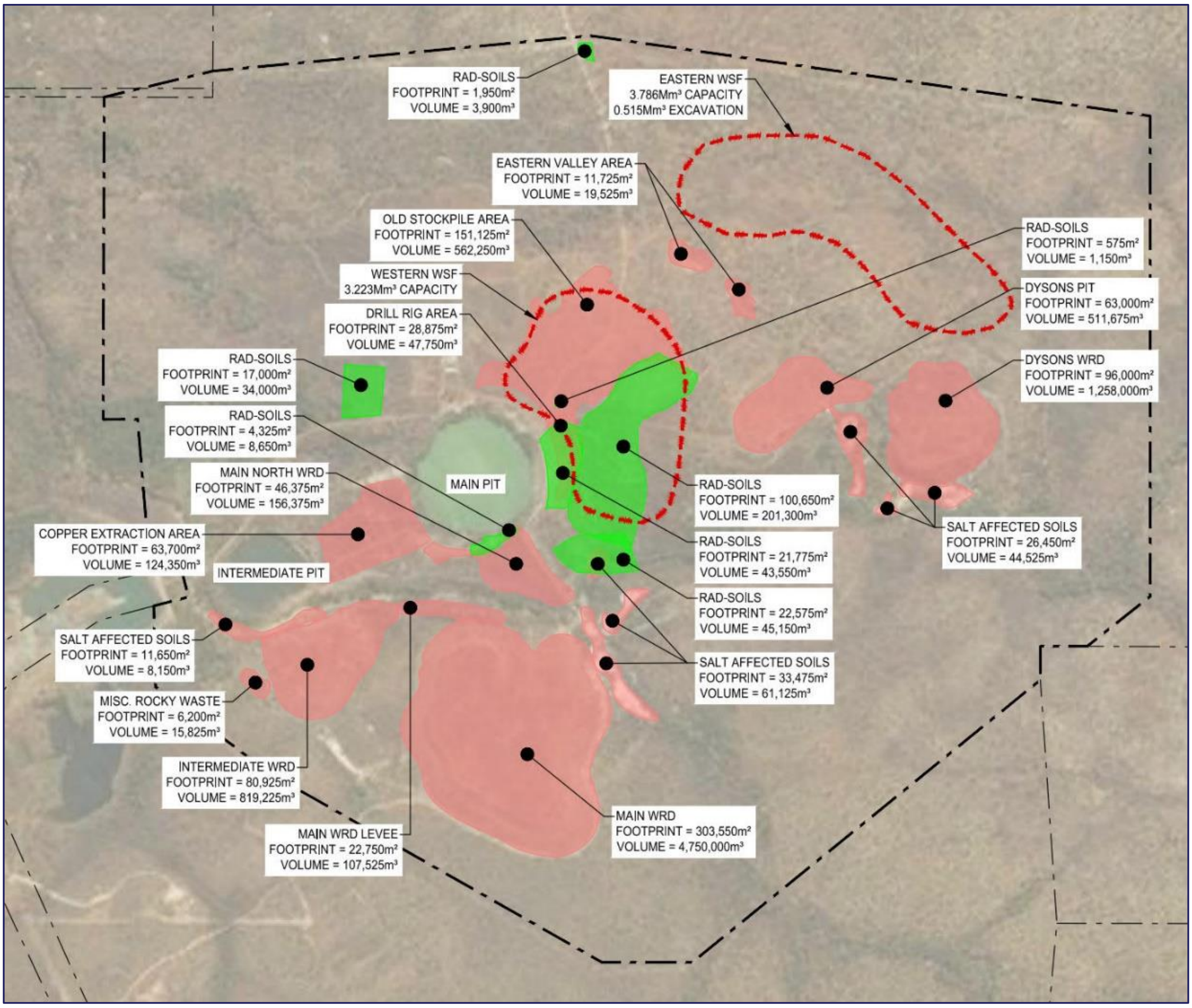


Figure 7-3: Earthworks Plan for Stage 3 rehabilitation (zoomed view of Figure 2-6 to allow view of detailed text)

### 7.4.1. Existing WRD Deconstruction Plan

The existing Main, Intermediate and Dyson's WRDs are to be deconstructed progressively over the Stage 3 works. The deconstruction methodology proposed has been developed to address, as far as practicable, the potential environmental and safety risks of handling AMD and low grade uranium materials. The deconstruction of each facility is to be carried out in vertical segments rather than horizontal slices to reduce, as far as practicable, the exposed surface area of waste rock. Minimising exposed waste rock surfaces is important during the Wet season as there is a high risk of mobilisation of existing contaminants and acid from the waste rock, resulting in further sulphide oxidation. This may create surface water runoff from the work area that has low pH and elevated heavy metals.

The existing cover systems will remain in place for as long as possible and will be stripped progressively, as needed, as a new vertical segment is prepared for relocation. Progressive cover stripping and reuse will reduce the need to import new cover materials and reduce double handling of the recycled cover materials. Additionally, it will minimise the volume of radon gas emanation from the low grade uranium waste rock that is likely to increase once existing earthen covers are removed. A schematic conceptual cross section of this Deconstruction Plan is provided in Figure 7-6.

As the PAF-I materials represent the highest environmental risk materials, these are scheduled for relocation in the Dry season only. An Erosion and Sediment Control Plan (ESCP) for site will be developed as part of the detailed design package that includes sediment containment for each work area. It is likely that the sediment pond for each work area will require additional pH adjustment.

Waste rock at Mt Burton is to be removed from its current location and imported to the main Rum Jungle site. This material is not characterised as potentially acid forming and the volume is low. This material will be relocated during the Dry season. Mt Fitch has no waste rock at surface however overburden stripped from the surface of the pit is locally stockpiled. This material is to be locally rehandled and is not characterised as potentially acid forming.

### 7.4.2. WRD Footprint Cover System

It is proposed to excavate the WRD down below natural ground surface to a nominal depth of 2 m in order to remove contaminants that have migrated from the overlying waste rock. It is recognised that there is likely to be residual contaminants in the remaining underlying unsaturated zone (the zone above the groundwater table). These contaminants are likely to be copper and other heavy metals, and acidic conditions. The priority for these contaminants is to isolate them from environmental and human receptors. In order to reduce the load within the unsaturated zone, it is proposed to leave the exposed WRD footprints open for up to two Wet seasons to allow contaminants to move vertically into the saturated groundwater zone for extraction *via* the SIS and treatment in the WTP.

After this two Wet season period, the top 0.2 m of substrate will be grid sampled, tested for paste soil pH and dosed accordingly with lime to achieve an approximate paste pH of 8. The final treatment will be to place a backfilled layer of growth substrate over the footprint to bring the final surface up to approximately 1 m above grade. In total, this depth of clean fill will range from 2-3 m over the WRD footprint. This is intended to result in a final landform that is water shedding for the purpose of slowing down any future release of final copper loads. The purpose of reducing this movement rate is to reduce the total load *per* year to the EBFR and improve quality of surface waters.

The growth substrate for the WRD footprint will not be exposed to high runoff velocities due to the low landform gradients, therefore the specifications for this material type will be more flexible than that proposed for the WSF. This will allow for use of clean fills from already disturbed onsite borrow footprints. Material property specifications will balance what is required to support revegetation with what is required to minimise erodibility. The vegetation systems planned for this area are described in the Ecological Restoration Strategy below.

## 7.5. Contaminated Soils

### 7.5.1. Copper Contaminated Soils

As noted in Chapter 6 – Existing Site Condition there is residual copper contaminated soils located at the old Copper Extraction Pad area. This location is marked on Figure 7-3. It is unlikely that this soil is contributing significant copper load to the EBFR. This surface does not support a stable vegetation cover.

The remediation plan for this area is to excavate the copper contaminated soils to a depth 2 m below the current surface elevation. It is likely that additional copper contamination within the unsaturated zone is present; however, the purpose of this excavation is to isolate this subsurface contamination from environmental and human receptors. This excavated material is to be relocated to the WSF. The top 0.2 m of substrate within the Copper Extraction Pad footprint will be grid sampled, tested for paste soil pH and dosed accordingly with lime to achieve an approximate paste pH of 8. A backfilled layer of growth substrate over the footprint will be placed to bring the final surface up to approximately 1 m above grade. In total, this depth of clean fill will range from 2-3 m over the footprint. This is intended to result in a final landform that is water shedding for the purpose of slowing down any future release of final copper loads.

The final surface design for this area must be completed in conjunction with the EBFR reconstruction design works, as the area will likely be seasonally inundated when bank break flows occur in the post-rehabilitation scenario. Material property specifications will balance what is required to support revegetation with what is required to minimise erodibility. The vegetation systems planned for this area are described in the Ecological Restoration Strategy below.

## 7.5.2. Dyson's Pit Backfill Cover System

As part of the earlier rehabilitation works described in Chapter 6 – Existing Site Condition, Dyson's Pit was partially backfilled with tailings from the Old Tailings Area and Tailings Creek, and copper extraction materials and contaminated soil from the heap leach trial area. A coarse geotextile and a nominally 1 m thick rock blanket drainage layer (below natural surface within the Dyson's Pit shell) was placed between the tailings and copper contaminated materials. A cover system and revegetation layer was also constructed. The copper extraction materials and soil are located above natural surface (Allen and Verhoeven, 1986) and are contributing to the copper loads reporting to the EBFR (Robertson GeoCconsultants, 2019a). This landform does not support a suitable level of vegetation growth in its current condition.

For remediation works, it is proposed to excavate the copper extraction materials and soil down to the rock blanket. For the purposes of worker safety and long-term safety, the existing rock blanket and below surface tailings will remain *in situ* because this provides a safe, long-term storage option. A new, clean cover system will be installed – consisting of an additional 1 m rock blanket over the existing rock blanket material, on top of which a 0.5 m low permeability clay layer will be placed. This low permeability clay layer will tie into the surrounding surfaces to facilitate horizontal surface water drainage and reduce vertical infiltration. A layer of coarser textured rock will be placed above the low permeability clay layer. This will provide a protective cover and drainage layer to transport up-gradient flow and net percolation waters through the system without contacting tailings. A 2 m growth medium layer will be placed above the coarse rock layer to provide a revegetation substrate with moisture-holding capacity that will store and release infiltrating water.

## 7.5.3. Radiological Soils

The Excavation Plan for the Stage 3 has been developed to address onsite radiological soil hazards. These include soils of the south-west face of the ridgeline located east of Main Pit, east of the old stockpile area and at specific 'hotspots' across the site as shown in Figure 7-3.

The footprint of the Western WSF incorporates the majority of the radiological soils mapped onsite and its positioning took into account value-engineering and safety-in-design considerations. This design approach has eliminated the need for a large portion of the radiological soils to be handled by Stage 3 workers as the material within the footprint will be covered *in situ* with layers of additional radiological soils and then further covers as described below.

The area of radiological soils outside of the Western WSF footprint is conservatively over-estimated to be 77,000 $m^2$, such that a predicted soil volume to 154,000 $m^3$ will be moved at a maximum 2 m cut depth. Evidence from investigation work indicates that the six radiological anomalies at the Rum Jungle site are related to historic mining practices. The RJ2 anomaly is a result of the old ore stockpile (within the Western WSF footprint) and the RJ1, RJ3, RJ4, RJTDN and RJTDN2 anomalies are thinly deposited layers of tailings or sediment transported from the ore stockpile area. Investigations indicate that a cut depth of 0.4 m should remove the source materials of these anomalies. For the purposes of conservative planning, a 2 m excavation depth is planned; however, it is likely that during excavation works a shallower cut may be taken based on testing throughout the excavation area.

In the first year of rehabilitation earthworks, radiological soils outside of the Western WSF footprint will be excavated, placed over existing radiological soils within that footprint and covered with a low permeability barrier blanket. The WSF will then be constructed over this radiological 'cell'. The relocation and burial of these materials early in the first year of the earthworks schedule will reduce overall worker exposure risks. Further information pertaining to operational safety aspects can be found in Chapter 15 – Human Health and Safety and Chapter 16 – Radiation, and the *Radiation Management Plan* (EcOz, 2019 – see Appendix).

As described in Chapter 6 – Existing Environmental Conditions, the identification of radiological soils is confounded by the mineralisation in the area. There is a possibility that Stage 2B works may identify localised pockets of soils that need to be relocated into the radiological cell, in addition to materials already nominated during the radiological hazard assessment; the volume of these materials would be low.

Some of the work areas for radiological soils are within the Restricted Work Areas as defined by the Authority Certificate and, as such, the relevant Custodians for these sites will be present during the removal activities (as detailed in the Authority Certificate).

### 7.5.4. Salt Affected Soils

The presence of white sulphate salts around site are described in Chapter 6 – Existing Site Condition. These salt affected areas contribute to 'first flush' contamination events at the commencement of each Wet season. The removal of the waste rock from the WRDs will resolve the long-term development of these salt affected soils and, after the waste rock has been relocated, the existing salt affected soils will be removed and stored within the WSF.

Some areas of salt affected soils are within the Restricted Work Areas as defined by the Authority Certificate and, as such, the relevant Custodians for these sites will be present during the removal activities (as detailed in the Authority Certificate).

### 7.5.5. Asbestos Containing Materials (ACMs)

The rehabilitation works program will include the identification and removal of ACM equipment and building materials from active work areas in initial site establishment phases. These will eventually be disposed of in a nominated location or 'cell' within the WSF, but may need to be temporarily aggregated and suitably covered until such time as the storage cell within the WSF is prepared. ACM will be identified and removed by suitably experienced and licensed asbestos specialists. This is an early project action to mitigate the potential for ongoing worker exposure to asbestos risks during the remainder of site rehabilitation works. It will negate ACM risks on site permanently.

An active Asbestos Register (has and) will be maintained throughout the duration of the project – to keep a continuous record of suspected ACMs and to action identification and management protocols (akin to an 'unexpected finds protocol').

There is a low likelihood of free asbestos fibres within the surface soils around the existing buildings because this surface area was stripped and backfilled in 1977 using the material from the lead ore stockpile and then reshaped, lime treated and revegetated in the 1984-1985 secondary rehabilitation period (Allen and Verhoeven, 1986). It is likely that any free asbestos fibres were either stripped or covered over during these works. However, this area will be utilised for the construction of new temporary facilities for Stage 3 (in the event that no agreement can be reached with Browns Oxide Mine for the lease of existing facilities). The area is to be sheeted with coarse, free-draining material to limit exposure of the workforce to potential contaminants in this area.

## 7.6. Scheduling

The scheduling and sequencing take into consideration the hazards mentioned above (Figure 7-4). Note that Figure 7-4 does not include the Year 1 ACM removal task as it is not primarily an earthmoving task. The schedule for all waste rock relocation activities will be refined and optimised using Deswik block modelling tools to ensure that all material constraints are considered and risks are adequately managed at the design phase. The Leading Practice Sustainable Development Program (DIIS, 2016) recommends this practice. The design and planning tools being utilised for this project are typical industry tools to ensure that information transfer between the current Stage 2A and planned Stage 3 stages is simplified, with reduced risk of error or data loss between Stages.

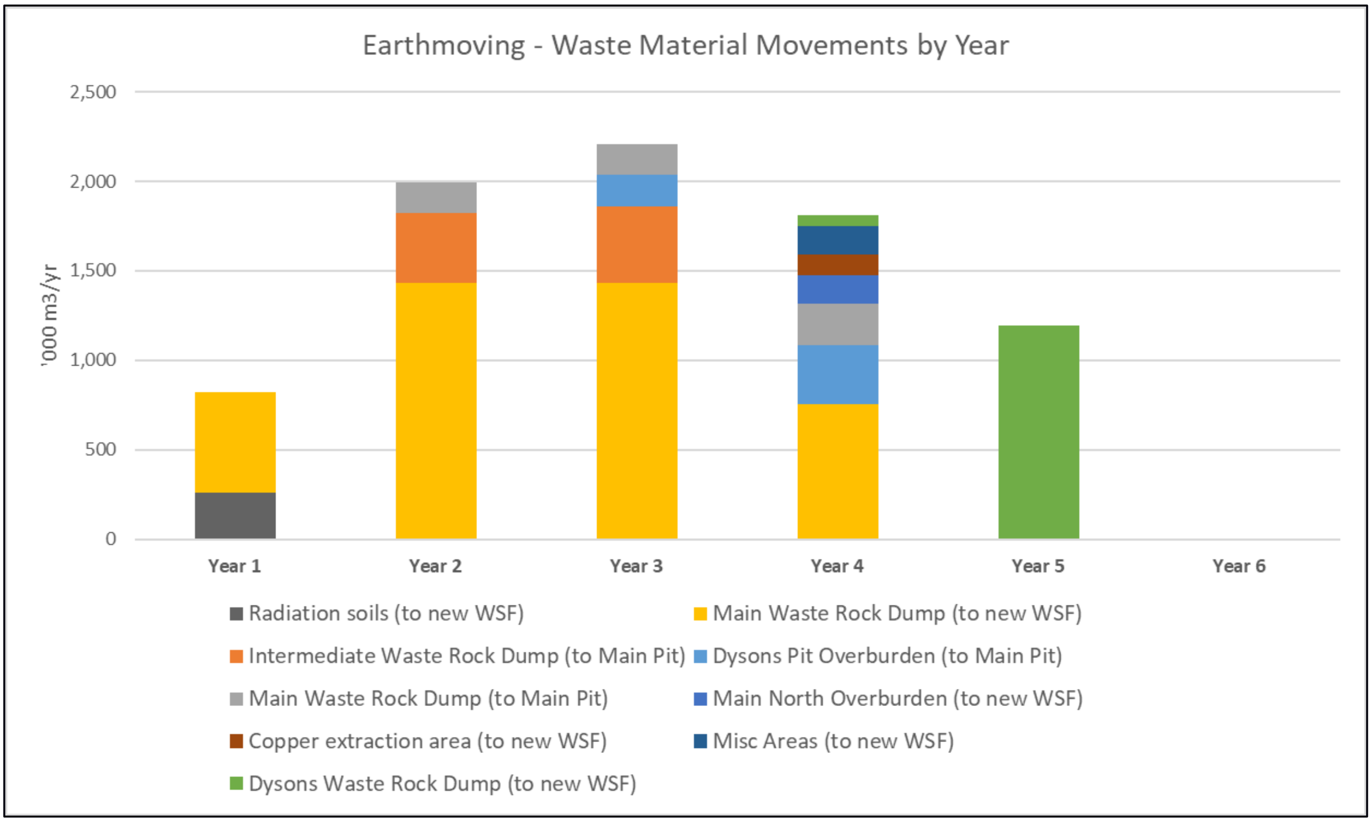


Figure 7-4: Earthmoving schedule

## 7.7. Main Pit Backfilling

The Main Pit is a registered sacred site and the project's Authority Certificate allows for rehabilitation of the Main Pit. The rehabilitation strategy for this pit includes utilising the storage volume for permanent containment of the existing uranium tailings which are already currently stored at depth. The remaining void will be used to store PAF-I waste rock. This material has been identified as coming from the Intermediate and Main WRDs, and Dyson's (backfilled) Pit.

The purpose of the backfilling and cover system is to:

- Isolate tailings currently stored at depth within Main Pit.
- Submerge and saturate lime-amended waste rock to reduce production of AMD from the highest risk acid forming materials (*i.e.* PAF-I), as *per* best practice standards.
- Provide a geotechnically stable landform that is safe for crest battering and revegetation.
- Provide a water cover under which the stored tailings and waste rock may settle and stabilise.
- Allow for geotechnically and geochemically safe conveyance of a portion of EBFR flows through the original path.
- Create a physical structure capable of supporting aquatic and ecological flora and fauna.

Backfilling will involve waste rock placement over the existing tailings through the water column *via* a floating barge and conveyor system. The barge will be anchored to the pit crest at several locations. A batch plant and pump will be located and controlled from a nearby laydown area and compound. The purpose of this batch plant is to deliver a sufficient quantity of lime to the waste rock stream to neutralise existing acidity and facilitate precipitation of metals from solution. The material supply to the barge will be supported by buoyancy aids. A conceptual cross-section is at Figure 7-5. The backfill material will be placed in layers to minimise excessive loading in localised areas, which may result in compromised structural integrity of tailings. From a quality control and quality assurance perspective, backfill materials will be routinely sampled at the batch plant and cap levels will be monitored by bathymetric analysis.

The final cover system over the backfilled waste rock will consist of a clean fill cover to isolate the waste rock and then overlying rock armouring to prevent scouring of the cover once EBFR flows are returned to Main Pit. The final layer in the capping system will be a water cover thus creating a pit lake. The minimum Dry season water level will provide a 1-2 m cover over the clean fill cover. This is sufficient to exclude oxygen from the underlying waste rock to constrain the acid forming processes. Predicted climate change impacts for the area indicate that extreme weather events are likely to become more common and rainfall is unlikely to reduce. Additionally the Intermediate Pit Lake will act to stabilise groundwater conditions in the long-term. Therefore the proposed water cover should prove suitable for longer term climate conditions.

The final Dry season water cover depth will be determined by a hydrodynamic assessment to ensure that sufficient engineering controls are in place to reduce the risk of cap scouring and entrainment into the EBFR. An additional consideration to this is to understand a suitable water depth that would encourage ecological restoration of the pit lake.

The pit lake edges will be battered and reshaped to stabilise the crests and provide a foundation on which to restore riparian vegetation and fauna passage. Final landform design will need to consider a geomorphological approach, principles of aquatic ecosystem restoration and hydraulic assessment to ensure that the landform is stable, ecosystems have the foundation for recovery and that water can safely pass through the pit lake.

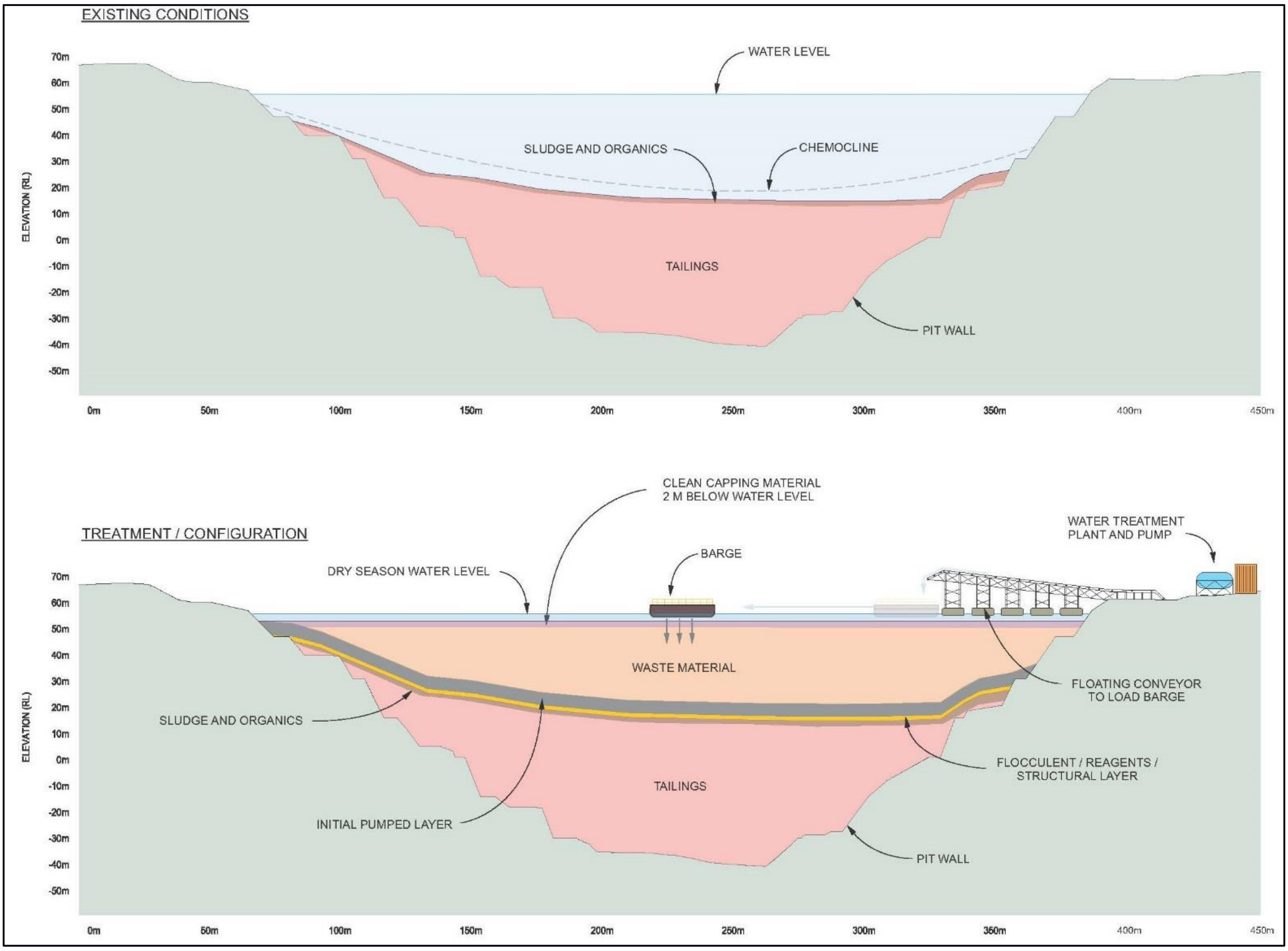


Figure 7-5: Schematic barge and conveyor system

The Intermediate Pit is not planned for backfilling in the Stage 3 scope of works for several reasons. Primarily, the Intermediate Pit is planned to be used as the final, passive water polishing facility onsite as well as a location where any sediment generated from newly rehabilitated landforms can drop out of suspension. Additionally, the Intermediate Pit is hydrogeologically connected to the EBFR and so any geochemical reaction within the Intermediate Pit would likely report some contaminant load to the EBFR.

### 7.7.1. Restoring EBFR Flow

A cornerstone of the cultural restoration of the Rum Jungle site is to restore, as far as possible, the original flow path of the EBFR. This will involve the reconstruction of a flow path that safely conveys water through the Main Pit Lake, the original river bed, the Intermediate Pt Lake and then out to the main channel of the East Branch. The existing diversion channel will remain to take flows that cannot be safely managed through the primary original path. This is expected to have a positive impact on restoration of site cultural values, seasonal passage of aquatic fauna, aquatic fauna colonisation of onsite features such as the Main Pit Lake and control of site AMD processes.

The reinstatement of the EBFR flow path will not significantly alter downstream hydrology. There may be a slight delay in 'wetting up' of this section of the watercourse as the Main and Intermediate Pits fill to the point of overflow. This potential impact is assessed in Chapter 11 – Hydrological Processes.

The reinstated channel will be designed in accordance with leading practice guidelines for channel restoration and reinstatement – *e.g.* ACARP (2014). This will include the following considerations:

- Replicating, as far as practicable, the morphological and hydraulic characteristics of the existing and adjacent East Branch channel. These include factors such as width, depth, instream bars and benches, bed material and substrate, roughness elements, slope, length and vegetation.
- Incorporate natural features present in the landscape and in local watercourses.
- Maintain equilibrium, functionality and stability.
- Consider longer term sediment supply, transport and fate within the context of the local conditions.

Key considerations for the reinstatement will include:

- The need to ensure passage for aquatic fauna through the pits and the reinstated channel. This will require flow velocities to accord to appropriate limits and the inclusion of areas of temporary refuge for migrating aquatic fauna using roughness elements, backwaters and the like.
- Establishment of a resilient vegetation community using appropriate and acceptable species to enhance natural values and provide erosion protection, particularly given the seasonal rainfall characteristics and potentially high flow rates. This will require establishment of a stable soil surface, and establishing both fast growing groundcover and slower growing shrubs and trees *via* seeding and the use of tubestock.
- Levees, as necessary, to reduce the risk of an avulsion or breakout of flows from the reinstated channel during higher flow events.
- Low weirs and diversion structures, as appropriate, to ensure the required flow split between the existing diversion and the reinstated channel is achieved.

Key considerations for the backfilled Main Pit are expected to include:

- Engineered entry and exit transition zones between the reinstated channel and both the Main and Intermediate Pits to ensure that erosion does not occur at these flow transition points.
- Covers over waste rock in the Main Pit, including erosion protection such as rip rap rock armour.
- Re-profiling of the pit rim edge area to allow vegetation to establish.
- Overland drainage management to prevent uncontrolled runoff into Main Pit from overland flow and any associated erosion and gullying.

An appropriately-qualified person will be engaged to support this design. It is proposed that progressive reinstatement of the East Branch flow through Main and Intermediate Pits takes place over a number of years. This is to ensure that land and vegetation systems have time to establish on the new alignment before introducing potentially high flood flows over the Wet season.

Eco Logical (2014) surveyed surrounding waterways for riparian vegetation condition. This report documents the good condition of Fitch Creek and the moderate condition of the East Branch, and provides an indication of analogue physical and ecological conditions adjacent to site.

# 7.8. New WSF Construction

The two new WSFs are located as shown in Figure 7-3. The relocation of waste rock and contaminated soils are to occur throughout all five years of the Stage 3 Construction phase (see Figure 7-4). The purpose of relocating the waste rock and contaminated soil is to store these materials safely in a manner that isolates contaminants from the environment and future land users, and stabilises the acid production reactions within the potentially acid forming waste rock. Contaminated soils are to be stored within the both WSFs. Waste rock is to be stored in one of three locations: Main Pit backfill, East WSF and West WSF.

The materials identified for storage at the WSF are the radiological soils, Dyson's WRD, Mt Burton WRD and the remaining volume of Main WRD materials that are excess to the Main Pit backfill storage volume. Transportation of contaminated soils and waste rock will be carried out using internal haul road networks, except in the case of Mt Burton, where waste rock will be hauled to the WSF along an existing road network.

The WSF has been designed to minimise future generation of acidic and saline seepage by minimising water and oxygen ingress, and to minimise erosion through selection of appropriate capping materials, final landform geometry and revegetation systems. Both the East and West WSF locations have been carefully selected to ensure that they are in areas that:

- are not prone to flooding in a 1:100 Average Recurrence Interval (ARI) event;
- have suitable foundation geotechnical stability;
- require minimal clearing of established vegetation;
- minimise re-handling of radiological soils by covering the major remnants *in situ*;
- do not disturb Aboriginal places, objects or artefacts; and
- do not present unacceptable visual amenity impacts.

The estimated storage capacity of the East WSF will be 3.8 $Mm^3$; while the capacity of the West WSF is estimated to be 3.2 $Mm^3$.

## 7.8.1. Foundation Preparation

This project step is necessary to prepare the WSF for relocation of waste rock and contaminated soils, and will be undertaken progressively over Years 1-5 of the Stage 3 Construction phase. This step provides the opportunity to maximise the re-use of excavated foundation materials for haul road and laydown area construction, and within the WSF cover system. Maximising the volume of materials sourced from within the WSF footprint will have a compounding improvement in the final WSF geometry because it increases the volume of stored waste rock below the natural surface whilst reducing the final facility height above grade. Additionally, optimisation of the materials sourced from within the WSF footprint will reduce demand from the borrow pits. This will result in reduced borrow pit footprints and reduced haulage impacts.

The foundation design will incorporate principles of monitored natural attenuation which is discussed below. A sealing berm will be incorporated at the waste rock/natural surface contact to direct incident surface water runoff away from the facility foundation and to reduce the emanation of toe seepage.

## 7.8.2. Waste Placement

It is critical to note that the long term chemical stability of the planned WSF landforms does not solely rely on the cover system described in Section 7.8.3. The placement methodology of the waste rock itself is critical in improving the chemical stability of the WSFs in the long term. According to a 2003 WRD review report by Taylor *et al*, waste was placed on the existing WRDs by 'end dumping of spil material from tipheads established along a centrally placed haul road'. As noted in Pearce, Lehane and Pearce (2016), the internal strucutres (chimneys) created within end-dumped facilities greater than 4-6 m height are likely to directly influence oxygen ingress, net percolation, gas flux, seepage flux, erosion and stability. Therefore the original placement methodology (end dumping) is likely to have led to the development of internal chimneys and preferential water pathways (Pearce *et al*, 2016). An assessment of dump construction methodologies by Pearce *et al* (2016) notes that paddock dumping (bottom up) is the only construction method where regular compaction of material is incorporated as part of the placement process which in itself should result in lower rates of oxygen ingress.

Although the WRDs were reshaped during the 1980s rehabilitation works, this would be unlikely to have amended internal structures and loose material consolidation formed from end-dumping. This facet can be substantially improved with a new construction methodology. The construction methodology and design for the WSF has been developed with the primary focus on long-term risk mitigation associated with future AMD and exposure of radiological materials. Primary controls for future AMD production are the elimination, as far as possible, of infiltration of water and influx of oxygen to reduce pyrite mineral oxidation and secondary mineral reactions. Key elements of the risk mitigation measures for long-term protection of environmental and cultural values are:

- Bottom-up (paddock dumping) construction methodology to avoid internal particle size segregation and settlement issues associated with a top-down or end-dumped approach.
- Upon placement, waste rock will be lime-treated and then compacted in controlled layers (each nominally 0.5 m) to increase density, water residence time and saturation, and create an alkaline environment.
- The WSF will be built up vertically over a number of cells to allow part or all of the cover system to be constructed prior to the Wet season for each cell.
- Construct outer surfaces to final geometry within the placement cycle to expedite final surfaces available for revegetation covers.
- Construction of cover systems progressively alongside the waste rock lifts and progressive revegetation of cells and cover system surfaces to reduce rainfall infiltration during construction and to stabilise the outer surfaces as rapidly as possible.
- Detailed block modelling (*i.e.* Deswik) and scheduling will be undertaken to ensure the optimal movement and placement of waste rock. The aim will be to ensure:
  - The PAF-II and PAF-III will be encapsulated at the lowest point of the WSFs.
  - Dyson's waste rock material, which is non-acid forming (NAF), will be placed as an oxygen scavenging layer over the PAF and beneath the formal cover system.

A conceptual schematic describing the cellular construction methodology is provided at Figure 7-6. The bottom-up construction methodology will include 0.5 m lift intervals in horizontal layers with areas equivalent to the operational 'cell'. The 0.5 m layer is sufficient to ensure efficient lime mixing and improved compaction intended to increase density and reduce oxygen ingress. The overall methodology will improve bearing capacity and reduce post-construction landform settlement. This approach is consistent with best practice for construction of WSFs containing PAF waste (DIIS, 2016).

#### *Lime dosing*

The waste rock at the WSF will be treated with finely crushed agricultural limestone ($CaCO_3$) to pH 7 prior to compaction of each layer. The primary purpose of lime treatment is to:

- Neutralise existing acidity within the PAF waste rock.
- Reduce solubility and mobility of currently mobile heavy metals (Cu, Ni, Co, Mg) within the rock waste media.

Secondary benefits of lime addition will be:

- Elevated pH greatly suppresses AMD generation process (kinetic inhibition)
- Enriched $CO_2$ atmosphere (produced by limestone neutralisation) in pore spaces within the WSF reduces $O_2$ flux.

A geochemical testing regime will be incorporated in the waste placement area work cycle. The purpose of the testing is to estimate the stored free acidity in each placed block and to deliver the correct lime dose required to adequately neutralise that block. Due to the heterogeneous nature of the current WRDs, it is difficult to develop an efficient and safe methodology for determining lime dose rates at the loading face (the existing WRD deconstruction work area). A waste placement area lime dose methodology has been developed (Jones, 2019 – see Appendix). The lime does methodology in the waste placement area is logical as the work space is larger, the methodology can be sequenced to match with geotechnical quality control work and will allow for a direct calculation of the required lime for the placed material.

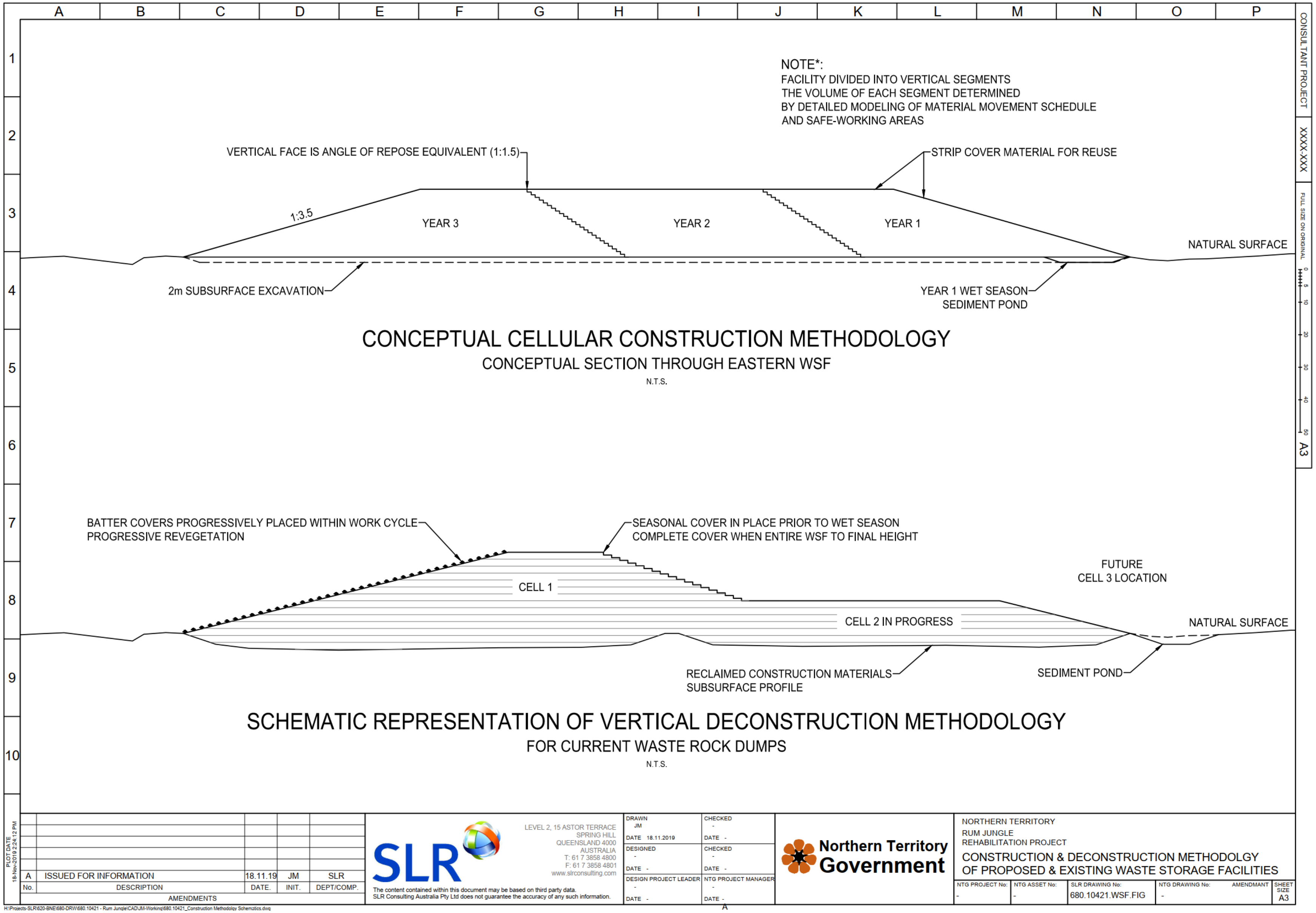


Figure 7-6: Conceptual vertical WRD deconstruction and cellular WSF construction methodologies

***Surface water management in construction***

Generally, the cellular WSF construction methodology is the same principle as that applied to the vertical segment deconstruction methodology described above for the WRDs. The purpose of both methodologies is to reduce the surface area to volume ratio for waste materials in order to reduce Wet season surface water impacts and to reduce further sulphide oxidation.

To minimise erosion risks and to maximise visual assimilation, the WSF batter gradients are designed at approximately 1 vertical to 4 horizontal (1:4 or 25%). Progressive capping and revegetation will improve surface water runoff quality from these completed surfaces during the Construction phase. The operational work surface areas will be minimised by the vertical cell construction methodology and infiltration into the rock matrix by liming and compaction; however, additional controls for managing surface water runoff are planned. Scheduling of high risk PAF-I waste rock material movement to the Dry season will significantly reduce the risk of Wet season work areas contributing to poor surface water quality during Stage 3 works. Finally, the ESCP will provide for a surface water collection sump on each work area where waters can be treated for pH and turbidity as required.

***Quality Assurance/Quality Control***

Quality assurance and quality control (QA/QC) will be an essential component of the WSF construction. As a component of the design package, a Quality Assurance and Control Plan will be completed and will be strictly enforced by site engineers. Dedicated and appropriately experienced construction supervision will be critical in achieving quality requirements. The Plan will specify the detailed testing, inspection and reporting requirements for the construction works and include triggers for remedial earthworks. This Plan will include both geotechnical and geochemical parameters in order to ensure structural integrity alongside sufficient chemical stabilisation of the AMD processes. A Construction Report will be produced at the completion of the project which will detail QA/QC results and any deviations from the specifications.

The Stage 3 Stabilisation and Monitoring Program is a proposed 5 year Post-construction phase where landforms and vegetation systems are intensely monitored and repaired as required. The QA/QC Plan for this phase will contain triggers for geotechnical stability, erosive stability, vegetation performance and water quality.

## 7.8.3. Cover System

A review of the current WRD cover system performance was carried out by Taylor *et al* in 2003 (see Appendix) and this review, along with broad industry review and best practice guidelines, have informed the design of an improved cover system for the WSF. It is important to note that the Rum Jungle WRD engineered covers were some of the earliest constructed in the world and naturally, industry experience in cover performance has grown since the time of their deisgn and construction (Taylor *et al*, 2003). Cover system performance was determined by measuring infiltration rates, oxygen influx, physical cover depths including layer profiles, observations on soil formation, termite colonisation, physical and biological processes altering the layer properties, root distribution and soil physical properties.

Key findings of this review were that while the properties of the layers had varied from specification (due to material availability at time of construction and biological and weathering processes since construction), the existing Main WRD covers were overbuilt compared to design in that the measured cover layer thicknesses were generally greater than designed as shown in Table 7-1 and Figure 7-7:

Table 7-1: Measured Cover Thickness (m) at Five Locations Compared to Design (Adapted from Taylor *et al*, 2003)

| Layer: | 2A Upper | 1B Middle | 1A Lower | All |
|---|---|---|---|---|
| | Erosion resistant layer | Store and release layer | Low Permeability layer | TOTAL |
| Design | 0.225 | 0.250 | 0.150 | 0.625 |
| A | 0.12 | 0.22 | 0.43 | 0.77 |
| B | 0.14 | 0.17 | 0.52 | 0.83 |
| C | - | 0.04 | 0.14 | 0.14 |
| D | 0.07 | 0.32 | 0.38 | 0.77 |
| E | 0.12 | 0.28 | 0.21 | 0.61 |

Sample points A to E were located on the upper flat surfaces of the Main WRD. Sample point C was located adjacent to a drainage line and the depth of cover is likely to have been modified by installation of the drainage line.

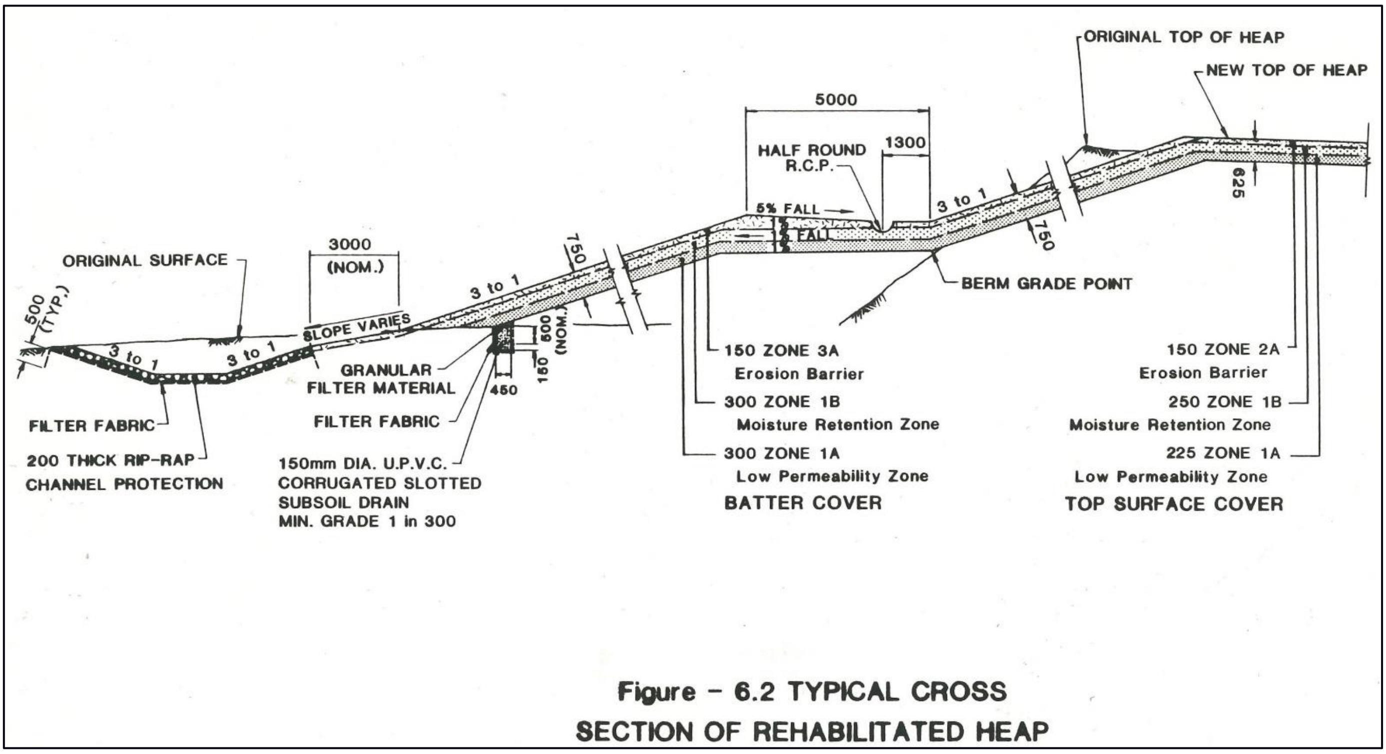


Figure 7-7: Section of Rehabiltated WRD (from Allen and Verhoeven, 1986)

Root penetration decreased with depth of cover and roots were found to have penetrated the low permeability 1A layer making use of voids created by termites or in the planar voids within the compacted clay layer. Roots were found within most of the waste rock/1A contact layers. Oxygen flux was found to be reduced by the cover system by 5 times when compared to the non-covered waste rock. Initial infiltration rates had been reduced to less than 5% of incident rainfall as *per* design however this had increased over time since construction.

The review found that a store and release cover system is appropriate however the thickness of the store-release layer should be increased to reduce drying of the deeper low permeability layer, reduce frequency of root penetration and termite activity within the low permeability layer and reduce overall oxygen influx. Modelling of oxygen flux and infiltration for any new cover systems were recommended. Additionally, instrumentation to measure success of the covers and adequate construction supervision and quality control were integral to the contruction process. Taylor *et al* (2003) also state that cover system design must make allowance for changes in permeability from root penetration and termite activity and the shrinkage characterisitcs of the available Zone 1A materials.

The cover system construction for the new WSFs will take place progressively over the life of the construction project. The purpose of the WSF cover system is two-fold: to limit oxygen and water ingress into the waste rock mass, and to develop a viable substrate for vegetation establishment. To meet these objectives, modelling has been undertaken and the resulting design is a 0.5 m low permeability barrier layer beneath a 2.0 m store and release layer (growth material) with internal capillary breaks/drainage layers. O'Kane Consultants (2013) developed the conceptual cover systems as described here. In addition, from an erosion protection and visual amenity perspective, the cover will require:

- a topsoil layer for inoculation of symbiotic soil microbes and nutrients;
- rock armouring to improve erosion protection;
- surface water drainage systems to safely convey plateau area catchment down to natural surface; and
- sufficient depth and drainage properties for root development (estimated as 2 m) for local grass and shrub species.

These layers are shown here in Figure 7-8 extracted from O'Kane Consultants (2013). Although the location of the WSF has changed since the 2013 draft design works, the cover system planned for the new WSF remains unchanged from the 2013 modelling and design:

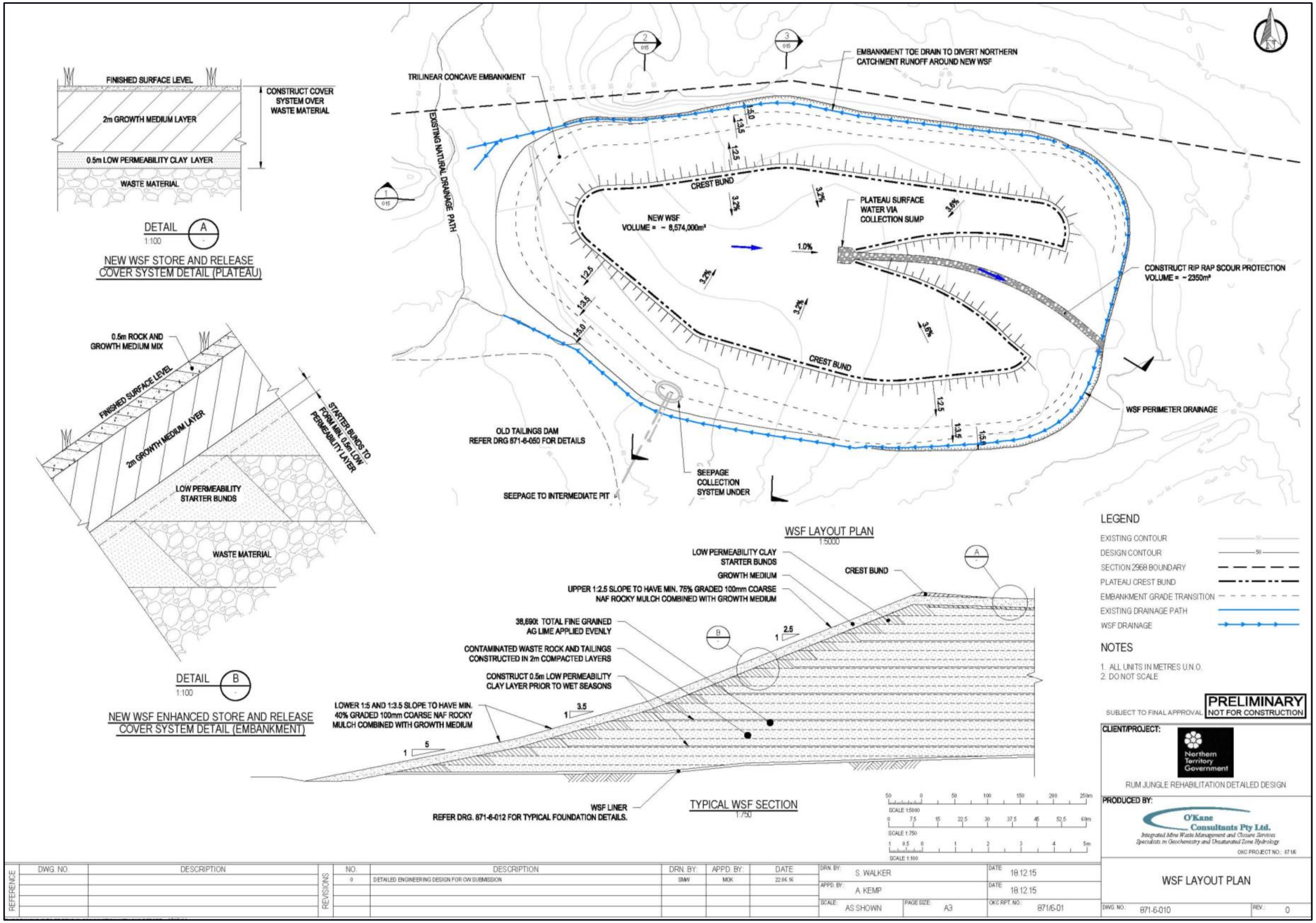


Figure 7-8: Typical Section through WSF (O'Kane Consultants, 2013)

The proposed Rum Jungle cover system meets the requirements of good practice covers as described in The Leading Practice Sustainable Development in Mining Series AMD Handbook (DIIS, 2016) which provides a conceptual cover system section describing key elements as shown in Figure 7-9.

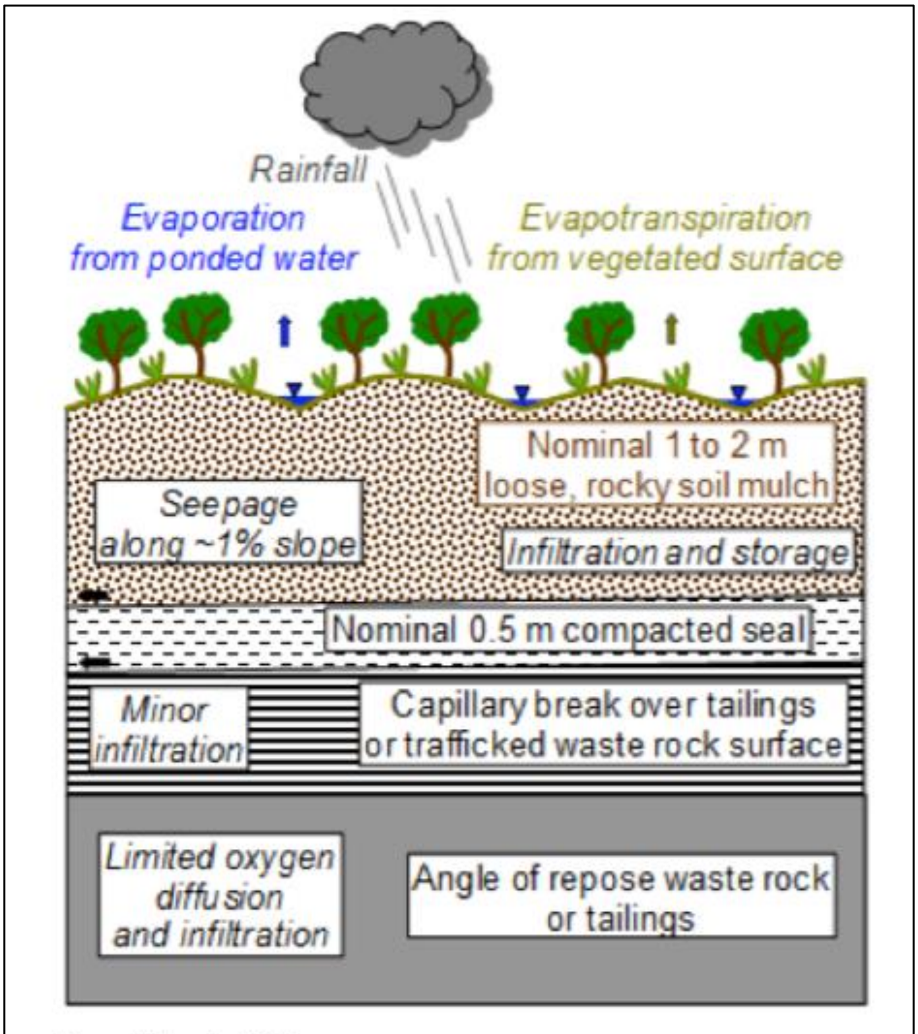


Figure 7-9: Store and Release cover system for seasonal climates

The seasonally Wet and Dry climate of the Batchelor area gives rise to challenges in managing a stable cover system. Experience in similar climates in Tanzania and Mali (Resolute Tanzania Ltd, 2011) indicates that these challenges typically include:

- Uncontrolled bushfire on newly-revegetated surfaces kills most seedlings/saplings and thereby reduces soil stability. Fire should be eliminated from newly revegetated areas for at least three years.
- Dry season vegetation cover die-off leads to low surface roughness and erosion protection at the start of the Wet season. Contour ripping on batter surfaces improves surface roughness.
- The limiting factor in successful vegetation establishment is often the lack of available soil moisture during the Dry season and growing season. Sufficient growth substrate with good moisture holding capacity (*i.e.* not broken unweathered rock) should be provided.
- Cover systems must include sufficient drainage systems to safely convey surface waters down to natural surface once covers reach saturation.
- Sufficient drainage systems from the plateau to natural surface must include crest berms to protect batter slopes from additional catchment volume reporting from the plateau area down the batter face.

- Colonising grass species have a role to play in stabilisation but also pose a fire risk and can rapidly outcompete seedlings of framework species. Species should be managed according to the risk profile of the particular revegetation surface.
- Cover physical properties, such as erodibility, must be well understood and adequate physical protection measures can then be employed.

The clean earthen materials required to develop the cover system for the WSF is to be sourced from within the WSF footprint as far as possible and then from two offsite borrow pits which are described below. Vegetation principles are discussed later in this chapter.

Rocky mulch armouring will be required on the lower batter surfaces of the WSF to improve the erosive stability of the cover system by increasing surface roughness and mitigating against sheet erosion. Flume erodibiilty testing has been completed for the cover materials and the results are documented below.

### 7.8.4. Drainage Systems

Surface water control is critical to ensuring erosive stability of the newly-formed WSF surfaces. The risk posed to erosive stability varies across the life of the facility and is directly related to meteorological conditions, physical material properties and establishment of vegetation systems. The design elements of the WSF surface water control system will include:

- Surface water drainage conveyance on and around the WSF, sized to accommodate a 1:100 year Annual Return Interval (ARI).
    - The WSF is placed within undulating topography therefore WSF/natural surface contact zones will require structures to safely convey upstream overland flow around the WSF to the downstream environment.
    - WSF plateaus will require long-term drop structures to safely convey water from the plateau down to natural surface. The route for these structures will utilise the existing natural topography to reduce the length of structure installed over the constructed landform.
- Site-specific erosion and sediment control (ESC) measures in place for both Construction and Post-construction phases. This will include rip-rap, conveyance channels, contouring *etc* as required and detailed within the ESCP.

The WSF is located within the EBFR catchment and, as such, all surface waters within these drainage systems will report to the EBFR.

### 7.8.5. WSF Seepage Management

Natural attenuation – as described by the NT EPA (2017) – includes the utilisation of naturally occurring processes to reduce the load, flux or toxicity of polluting substances. The WSF storage methodology is a clear example of utilisation of a pH-controlled environment to attenuate copper and other metals. The remaining mobile copper load is predicted to be negligible/very low from the newly formed WSF. This is modelled as detailed in Chapter 10 – Inland Water Environmental Quality. Copper loads reporting from the new facility is predicted to be at levels well below that which would cause impact to flora, fauna and human health. Throughout this process, secondary reaction minerals may be produced and it is likely that calcium, sodium and magnesium sulphates will be produced as a result of the acid neutralisation and metals attenuation process.

In order to reduce future management burden as far as possible, potential seepage generation from the WSF will be managed *via* natural attenuation processes. The primary Contaminants of Concern (copper and other heavy metals) are predicted to remain attenuated within the waste rock mass; however, saline drainage may form from within the WSF. It is proposed to direct seepage internally to the WSF to encourage vertical migration of seepage into the underlying rock mass. The volume of saline drainage will be reduced as far as possible through the methodologies of surface capping and stored rock mass density increase by compaction. The seepage quality is expected to contain magnesium and calcium sulphates with very low metals concentrations. This has been modelled in Chapter 10 – Inland Water Environmental Quality and indicates very low loading due to the low anticipated volume. A monitoring program for this approach is described in Chapter 10 – Inland Water Environmental Quality.

## 7.9. Borrow and Other Materials

Construction of the cover system installation will occur throughout all five years of the Construction phase. Cover materials are to be sourced preferentially from within the WSF footprint and then from two potential borrow areas located on (a) the adjacent FRALT and (b) a freehold parcel held by CCGC.

Preliminary investigation into the material types available within the WSF footprint indicates that approximately 475,000 m$^3$ of suitable material may be present within the foundation of the Eastern WSF (see Figure 7-10). There is material available within the Western WSF; however' it is overlain with bogum (below ore grade uranium material) which makes the recovery of suitable soils a hazard for human health, as well as uneconomical.

It is estimated that 3,687,000 m$^3$ of total cover material will be required to complete the works for the WSF and the Main Pit backfill cover system. Additionally, it is estimated that approximately 385,000 m$^3$ of low permeability material and 3.3 Mm$^3$ of growth material will be required for the project. These materials will be transported to site using both public and private roads at approximately 58-65 truckloads *per* day for the five years. The potential borrow sources on FRALT and CCGC land are shown in Figure 7-11.

It is critical to note that at the time of producing this EIS, no formal agreements have been developed between the Proponent and the proposed borrow pit landowners, although preliminary discussions have taken place. These potential borrow locations have been selected for inclusion within the EIS as:

- the correct material types are present;
- they have been assessed for low ecological (see Chapter 14 – Terrestrial Flora and Fauna) and cultural values;
- they are within a reasonable haul distance;
- no sacred sites, objects or places are present, and
- they provide a development opportunity for critical project stakeholders – Traditional Owners and CCGC.

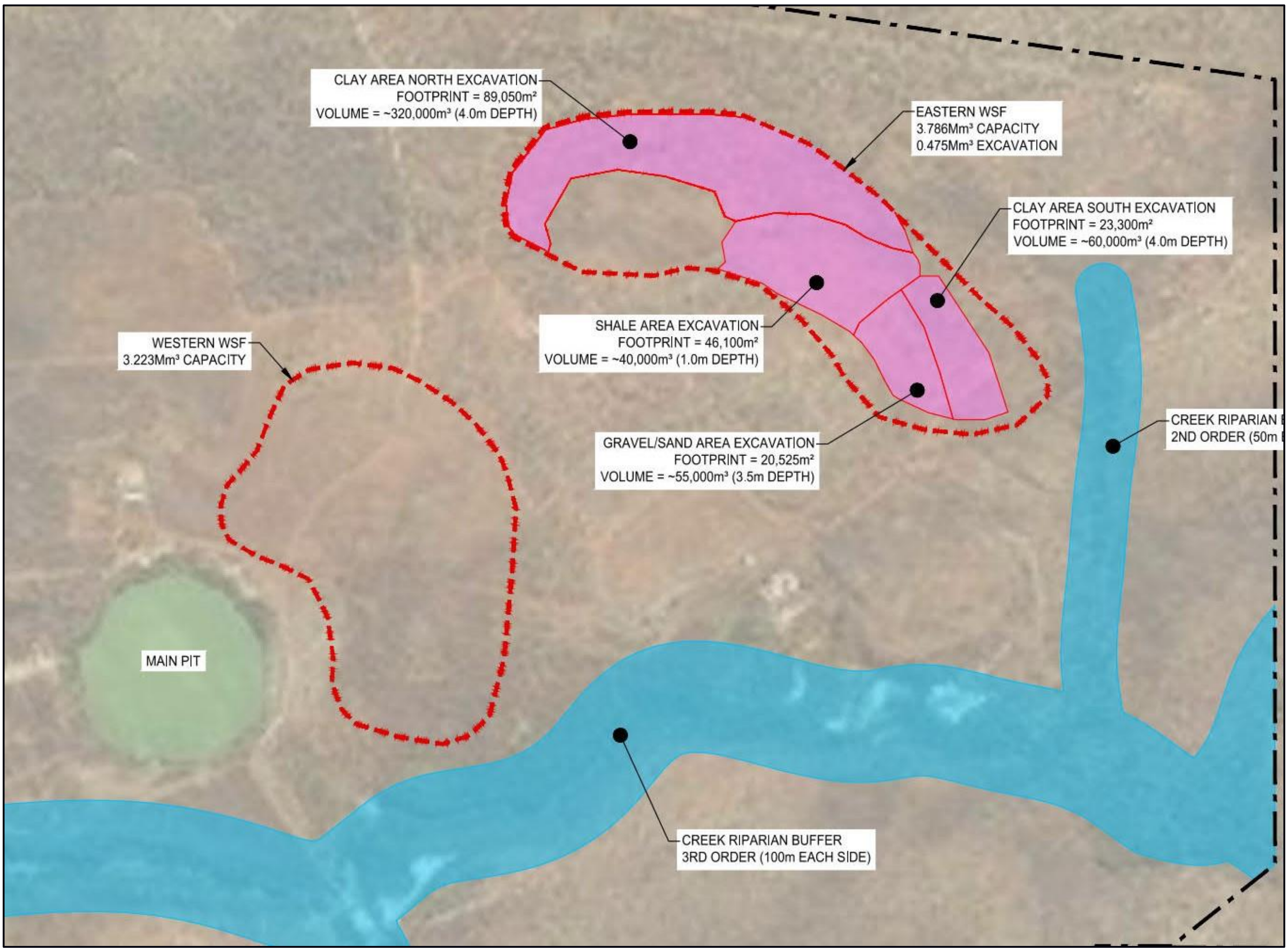


Figure 7-10: WSF footprint preliminary investigation into recoverable soils

***Borrow materials quality***

The borrow materials were sampled and tested for geotechnical and chemical parameters, and erodibility by SLR. This information was interpreted by GHD (2019d – see Appendix). In summary:

- SLR's assessment of the CCGC borrow area materials against ideal characteristics (derived from industry standards), indicates the materials have sufficiently low permeability (< $10^{-8}$ m/s) for use in the low permeability layer of the capping system for the WSF.
- SLR's assessment of growth material from the CCGC and FRALT borrow areas indicates sufficient volume of suitable quality material to replicate the soil profile of a Kandosol, typical of the Rum Jungle area and ideal for the support of local vegetation species over the WSF. Material from both potential borrow areas were found to be generally non-dispersive.
- GHD's assessment of geochemical properties against the Health Investigation Level C – Recreational (modified for temporary occupation scenario) indicate the results are well below these values.

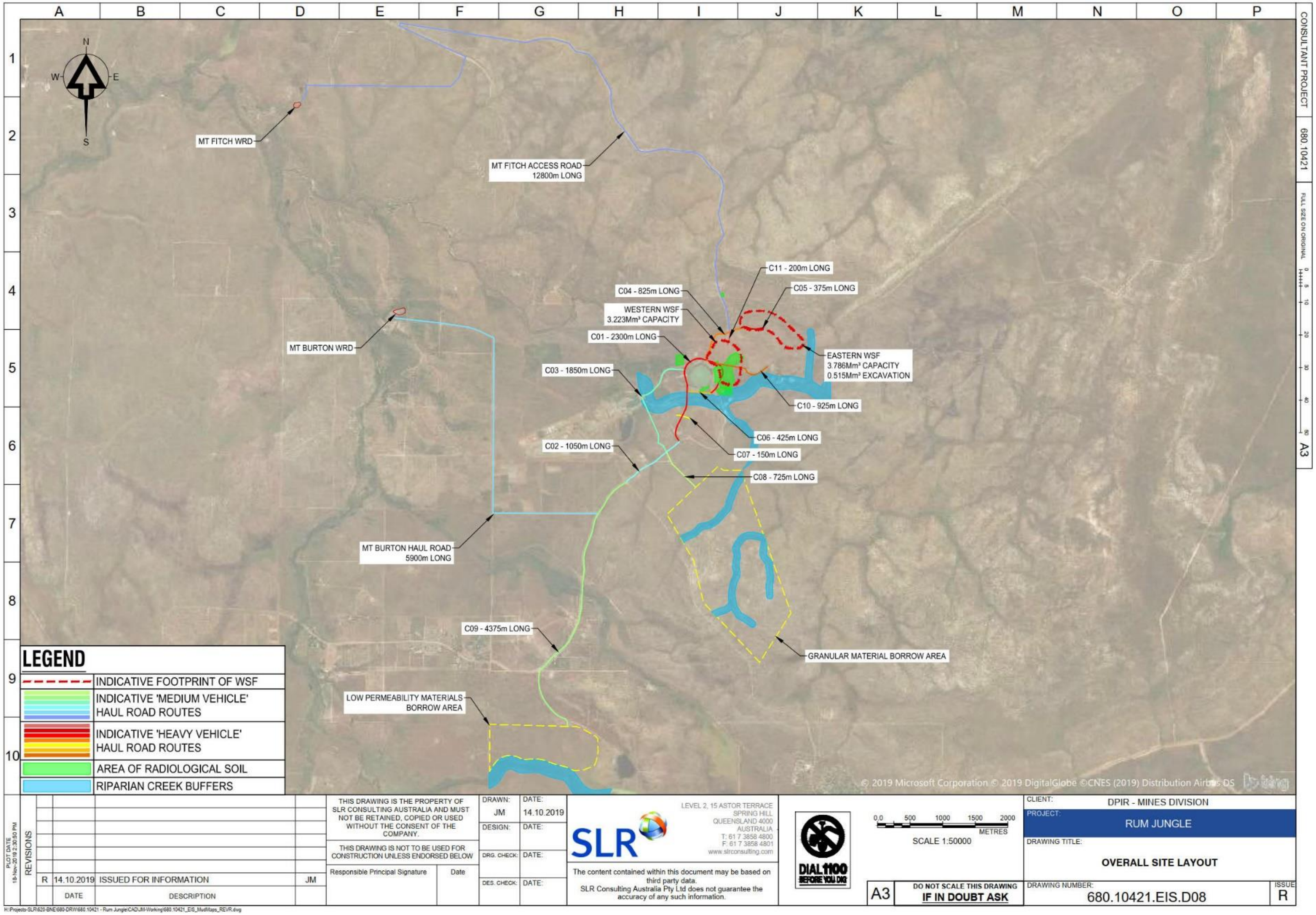


Figure 7-11: Potential borrow pits

# 7.10. Water Management

## 7.10.1. Water Treatment

The AMD-impacted groundwater plumes across the Rum Jungle site are contributing to loads of copper and other metals within the EBFR. A groundwater capture and treatment system (SIS) is proposed for the plumes within the Main and Intermediate WRD zone because this is contributing the most significant load to the EBFR. Full details for this proposal are described in Chapter 10 – Inland Water Environmental Quality.

In addition to groundwater treatment, surface water treatment will be required for the Main and Intermediate Pit system during the Main Pit backfilling operation. The pits will be isolated from the main flows upstream within the EBFR; however, the incident rainfall and groundwater inflows for the pit catchments will require removal in order to maintain safe operating levels within the backfill system. This is described in more detail in Chapter 10 – Inland Water Environmental Quality and Chapter 11 – Hydrological Processes.

A WTP will therefore be required to treat both ground and surface waters of varying degrees of quality and quantity because this is a highly dynamic system due to the strong seasonality of the site. The WTP will be designed to a 'construction ready' level as part of the development of the detailed design package. The water quality output from this WTP is to match LDWQOs as detailed in Chapter 10 – Inland Water Environmental Quality and Chapter 11 – Hydrological Processes. A summary of water management infrastructure is shown here in Figure 7-12.

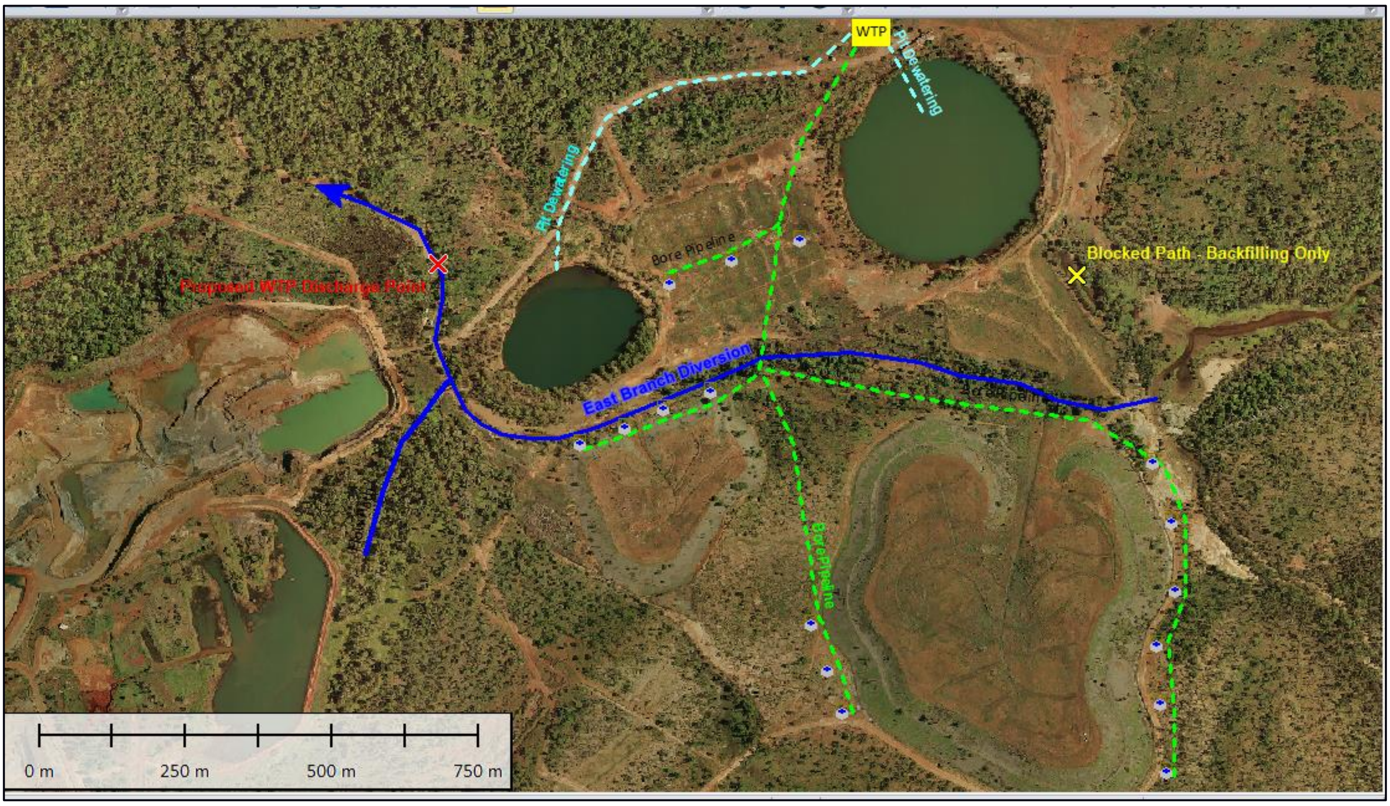


Figure 7-12: Water Management Infrastructure

## 7.10.2. Surface Water Management

A key element of the Stage 3 construction works is the backfilling of Main Pit. This is currently scheduled to take approximately three years and is planned to run through both the Wet and Dry seasons. In order to do this task, surface water flows onsite will have to be well managed to avoid impacts to worker safety and backfilling equipment, and to protect offsite water quality during the backfilling process. Components of this water management process (see Figure 7-12) include:

1. Ensuring 100% of East Branch flows are diverted to the existing diversion channel (*i.e.* EFDC).
2. Ensuring the maximum local pit catchments are re-diverted away from the Main and Intermediate Pits.

3. Utilising the Intermediate and Main Pits as 'live storage' volumes to absorb potential high rainfall events and reduce the chance of pit overtopping as far as possible. To this end:
   a. Intermediate Pit will be drawn down to 8-9 m below the invert elevation of the outlet; and
   b. Main Pit will be drawn down to an operational elevation of 1-2 m below the invert elevation of the outlet.
4. Continuous pumping and treatment of Intermediate and Main Pit waters during the three year operational phase to maintain these levels. The water treatment volume will be equal to the volumetric displacement due to Main Pit backfilling, groundwater inflows and surface water inflows (Wet season only).
5. A WTP to treat the surface and ground waters prior to release from site.
6. An Emergency Management Plan in the event of predicted extreme rainfall events (for example cyclones) to ensure worker safety, and protection of equipment and property.

The operational water levels for the pits are considered conservative for the three year operational phase and have been selected based on the following considerations:

1. The Intermediate Pit acts as a sink for some AMD-impacted groundwater flows from the Intermediate and Main WRDs. Drawdown of the Intermediate Pit will draw an increased flow of AMD-impacted groundwater into the pit thus deteriorating its water quality. Excessive drawdown of the Intermediate Pit is likely to cause significant deterioration to the Intermediate Pit water quality.
2. The Intermediate Pit is connected by groundwater to the East Branch and water quality of the Intermediate Pit itself can cause impact to the East Branch *via* groundwater movement.
3. The Intermediate Pit is connected by groundwater to the GDE to the north of the Intermediate Pit. This vine forest would be adversely impacted by excessive drawdown of the Intermediate Pit.
4. The Main Pit is to be backfilled by an overwater conveyor and barge setup. This requires a minimum freeboard in which to operate. Additionally, geotechnical stability of the Main Pit crest is at risk under excessive pit water drawdown. This would present an unacceptable safety risk.
5. The nominated operational water levels were modelled against rainfall events that have occurred within the 45 year dataset of events captured at GS8150097. This configuration of pit water elevations would allow for capture of all high rainfall events within the dataset, except for Tropical Cyclone Carlos.

It is likely that the Main Pit water quality will deteriorate during backfilling operations because the existing chemocline is likely to be disturbed and vertical water column mixing may occur. Additionally, the placement of waste rock materials that have been on surface for up to 70 years into the water filled void is likely to cause solutes within the waste rock to dissolve. It is imperative that pH control of the Main Pit Lake is maintained to precipitate high risk heavy metals and to reduce further acidification. However, soluble salts such as calcium, magnesium, potassium and sodium sulphate are likely to readily dissolve into solution. The water quality during backfilling is difficult to predict; therefore, the most critical controls for environmental protection are the WTP and the maintenance of a 'live storage' volume as described above.

## 7.11. Ecological Rehabilitation Strategy

Successful rehabilitation of the Rum Jungle Mine site depends on the creation of stable landforms which, in turn, depend significantly on adequate and sustainable revegetation. Additionally, ecological rehabilitation has been requested by the Traditional Owners. This section presents the Ecological Rehabilitation Strategy for the project. It draws on the experiences of other mines in northern Australia and overseas, as well as the results from the revegetation trial undertaken at Rum Jungle. The Ecological Restoration Strategy provides a basis for more detailed future plans.

Ecological rehabilitation, as presented here, focusses on establishing the finer physical elements required for ecological function of a site, as against the bulk remediation earthworks described above in Sections 7.3 to 7.9. Additionally, a Revegetation Strategy is presented.

### 7.11.1. Objectives

Key rehabilitation aims for the Rum Jungle Mine site are creating a safe and stable environment and reducing offsite impacts. In addition, Traditional Owners desire that the site supports flora and fauna species endemic to the area. To support these aims, active ecological restoration of all historically and planned disturbed areas will be undertaken. The primary objective of this is:

> *Return site landforms to safe, stable and sustainable systems using endemic plant species to stabilise constructed surfaces and restore living systems across all site surfaces.*

That the revegetated areas transition to vegetation communities akin to those at analogue sites is an aspiration, but not a goal that will be pursued to the detriment of the objective mentioned above. For example, a modified revegetation system will be required on the WSF because the role of vegetation on that facility is to mitigate erosive forces while protecting underlying compacted barrier layers from tree root penetration. Additionally, the restoration program provides an opportunity to incorporate structural elements to enhance fauna recolonisation. This is to include elements specific to the threatened species (and culturally-significant fauna) known to have previously or currently exist on and around site.

Rehabilitation at Rum Jungle will involve the creation of a range of environments (*e.g.* re-aligned river channel, WSF, borrow pits, roads *etc*). Given the history of disturbance and the nature of the substrate, many of these environments will pose significant challenges for rehabilitation.

***Risks***

The most significant risks to the success of the ecological restoration program are the following threatening processes: weed invasion (particularly Gamba Grass), uncontrolled fire and feral animals. These processes are active regionally and will present an ongoing challenge to all land managers going forward. The future evaluation of ecological rehabilitation success must be made in context of prevailing threatening processes and the strategy must include mitigation measures for these threatening processes.

## 7.11.2. Domain-based Strategy

The Rum Jungle Stage 3 Rehabilitation Project area has been divided into several domains that reflect the organisation of the landscape into zones with similar rehabilitation strategies aimed at delivering specific results. These areas are shown here in Figure 7-13 and a high level strategy summary has been developed and is available in Table 7-1.

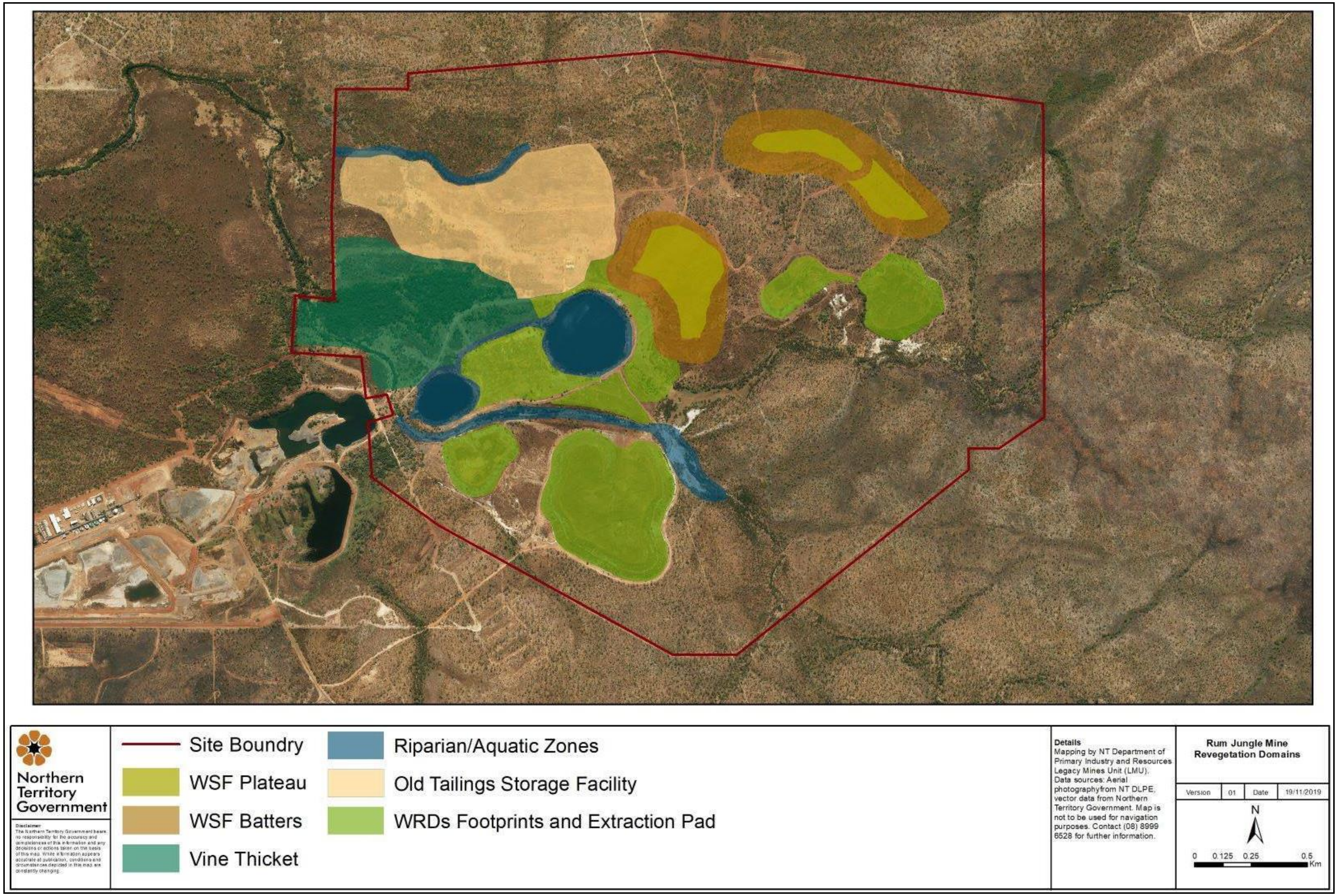


Figure 7-13: Domain map

Table 7-1: Rum Jungle domain rehabilitation strategy

| Domain | Surrounding Vegetation Types | Objective | Area (ha) | Gradient (%) | Fauna Elements* | Target Vegetation Type | Species in Target Vegetation Type |
|---|---|---|---|---|---|---|---|
| WSF Batters | *E. tetrodonta, E. miniata, E. chlorostachys* woodland to open forest and *E. tetradonta, E. miniata, C, polysciada* open woodland | Stabilisation | 48 | 25 | Nil | Modified: 6, 8, 10, 15 | *Buchanania obovata, Cochlospermum fraseri, Livistona humilis, Sorghum intrans, Petalostigma quadriloculare, Cycas armstrongii, Gardena megasperma, Grevillea decurrens, Calytrix exstiulata, Heteropogon triticeus, Bothriochloa bladhii, Heteropogon contortus* |
| WSF Plateau | *E. tetrodonta, E. miniata, E. chlorostachys* woodland to open forest and *E. tetradonta, E. miniata, C, polysciada* open woodland | Stabilisation | 24 | 0-5 | RM | Modified: 6, 8, 10, 16 | *Buchanania obovata, Cochlospermum fraseri, Livistona humilis, Sorghum intrans, Petalostigma quadriloculare, Cycas armstrongii, Gardena megasperma, Grevillea decurrens, Calytrix exstiulata, Heteropogon triticeus, Bothriochloa bladhii, Heteropogon contortus* |
| Dyson's (backfilled) Pit | *E. tetrodonta, E. miniata, E. chlorostachys* woodland to open forest and *E. tetradonta, E. miniata* open woodland | Stabilisation | 6 | 0-5 | RM | Modified: 6, 8, 10, 16 | *Buchanania obovata, Cochlospermum fraseri, Livistona humilis, Sorghum intrans, Petalostigma quadriloculare, Cycas armstrongii, Gardena megasperma, Grevillea decurrens, Calytrix exstiulata, Heteropogon triticeus, Bothriochloa bladhii, Heteropogon contortus* |
| WRD Footprints inc Cu Extraction Pad | *E. tetrodonta, E. miniata* open woodland and *Erythrophleum chlorostachys, Terminalia ferdinandiana* open woodland and *E. tetrodonta, E. miniata, E. chlorostachys* woodland to open forest | Ecological restoration | 61 | 0-5 | RM, HG, PS | Open Woodland: 5, 7, 8, 10 | *E. tetrodonta, E. miniata, Erythrophleum chlorostachys, Terminalia ferdinandiana, E. tetrodonta, E. miniata, E. chlorostachys, E. tectifica, C. polyscidia, Xanthostemon paradoxus, Owenia vernicose, Corymbia bleeseri, Livistona humilis, Cycas armstrongii, Gardena megasperma, Grevillea decurrens, Corymbia grandiflora, Corymbia foelscheana, Buchanania obovata, Calytrix exstiulata, Dodonaea hispidula, Brachychiton megaphyllus, Heteropogon triticeus* |
| Old Tailings Dam | *Acacia auriculiformis* vine forest, *Corymbia bella, C. polycarpa, C. foelsheana* open woodland to woodland and Melaleuca spp woodland | Ecological restoration | 32 | 0-5 | RM, HG, PS | Open woodland, Melaleuca riparian (north) and vine forest (south): 1, 3, 4 | *E. tetrodonta, E. miniata, Erythrophleum chlorostachys, Terminalia ferdinandiana, E. tetrodonta, E. miniata, E. chlorostachys, Acacia auriculiformis, Corymbia bella, C. polycarpa, C. foelsheana, Livistona humilis, Breynia cemua, Planchonia careya, Ficus aculeata* |
| Vine Thicket | *Acacia auriculiformis* vine forest | Ecological restoration | 25 | 0-5 | HG | *Acacia auriculiformis* vine forest: 1 | *Acacia auriculiformis, Terminalia macrocarpa, Erythrophleum chlorostachys, Corymbia bella, Ficus spp., Mallotusphilippensis, Polyalthia australies, Ganophyllum falcatum, Cupaniopsis anacardioides.* |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Riparian (EBFR, EFDC, Main Pit) | Grevillea pteridifolia, Pandanus spiralis, Melaleuca viridiflora open woodland to open forest and Lophostemon grandiflorus, M. spp. Woodland to open forest. | Ecological restoration | 15 | 0-10 | HG, PS, LWD | Riaprian woodland to open forest: 20, 21, 22, 23, 24 | Grasslands (flood zones): *Themeda triandra, Eriachne burkittii, Ischaemum australe*. Riparian woodland: *Grevillea pteridifolia, Pandanus spiralis, M. viridiflora, Lophostemon grandiflorus, M. dealbata, Corymbia bella, C. polycarpa, B. acutangula, Leptospermum longifolia, Timonius timon, Lophostemon lactifuus, Melaleuca cajuputi, M. leucadendra, M. cajuputi. Terminalia carpentariae, Ficus platypoda, Ficus virens, Brenynia cernuna, Strychnos lucida, A. auriculiformis,* |
| Mt Burton ** | Wet rainforest | Ecological restoration | 2 | 0-5 | Nil | Open Woodland | *E. miniata / E. tetrodonta* (Darwin Stringybark) with *E. confertiflora, Erythrophleum chlorostachys, E. tectifica* and *Corymbia foelscheana.*<br>Mid storey *Acacia spp., Cycas armstrongii, Brachychiton megaphyllus* and *Livistona humilis* |
| Mt Fitch | *E. miniata* and *C. polysciada* woodland and *C. bella* and *C. polysciada* open riparian woodland | Ecological restoration | 2 | 0-5 | Nil | Woodland and Open Riparian Woodland | - *E. minata, C.polysciadia* and *E. chlorostachys.* Prominent midstorey of *Calytrix exstipulata, Grevillea spp, L. humilis, Terminalia ferdinandiana and Xanthostemon paradoxus.* Lower storey *Sorgum intrans* and *S. timorense.*<br>- *C. bella,* absence of midstorey, lower dominated by *E. burkittii* and *G. grandiflora.* |
| Roads | Varies across locations | Retain or Ecological restoration | Varies | 0-10 | HG, PS | Roads vary depending on location | Depends on location |
| Borrow – FRALT** | *E. tetrodonta, E. miniata, Erythrophleum chlorostachys* mid woodland | Ecological restoration | 60 | 0-10 | HG | Mid Woodland | *E. miniata, Erythrophleum chlorostachys* mid open woodland over *Eucalyptus phoenicea, Terminalia ferdinandiana, Livistona humilis* over *Chrysopogon latifolius, Heteropogon triticeus, Sorghum intrans, Sorghum plumosum* |
| Borrow – CCGC** | *E. tetradonta* woodland and *E. miniata* woodland | Ecological restoration | 45 | 0-10 | Nil | Woodland | *E. tetradonta, E. miniata, E. confertiflora, Coymbia polycarpa, E. papuana, Corymbia grandifolia, Erythrophleum chlorostachys, Pandanus spiralis.* |

*C. = Corymbia, E. = Eucalyptus*

| | | | |
|---|---|---|---|
| *LWD | Large Woody Debris | HG | Hollow Logs on Ground |
| PS | Pandanus Stands | RM | Rocky Mounds |

** Final rehabilitation goals to be established with landholder. Minimum will be described in this Table.

The domains are described briefly here:

- WSF Batters – includes the sloped outer batter surfaces of the WSF. The vegetation must be shallow rooted to maintain cover system integrity and not include bush tucker plants to avoid any long-term exposure pathway for metals to the environment or people. The purpose of the vegetation is to establish quickly and provide a long-term vegetative cover for the WSF to improve resistance to erosion.
- WSF Plateau – refers to the flatter top surfaces of the WSF. The vegetation must be shallow rooted to maintain cover system integrity and not include bush tucker plants to avoid any long-term exposure pathway for metals to the environment or people. The purpose of the vegetation is to establish quickly and provide a long-term vegetative cover for the WSF to improve resistance to erosion.
- WRD Footprints – includes the stripped and backfilled surfaces close to natural ground level that will remain after completion of the waste rock removal at the current Main, Intermediate and Dyson's WRDs. These areas will be relatively flat. There are fewer limitations to vegetation requirements within this domain.
- Dyson's (backfilled) Pit – refers to the new surface developed after removal of the copper extraction materials and soil. The vegetation must be shallow rooted to maintain cover system integrity and not include bush tucker plants to avoid any long-term exposure pathway for metals to the environment or people. The purpose of the vegetation is to establish quickly and provide a long-term vegetative cover to improve resistance to erosion.
- Old Tailings Dam – the area was previously rehabilitated; however, the current condition is poor due to the invasion of weeds and repeated bushfires. This area requires physical improvement to reduce fire impacts. Vegetation types in this area is unrestricted and will be the trial area for which revegetation systems will be established.
- Vine Thicket – an area north of Intermediate Pit that is naturally occurring but heavily impacted at its edges by weeds and fire. There are few restrictions on vegetation types. It will provide a trial area to establish revegetation and fauna restoration systems.
- Riparian – refers to all areas along watercourses that are yet to be constructed (EBFR, Main Pit riparian zone) or currently exist in a poor condition.
- Mt Burton – a satellite site surrounded by high ecological value monsoon wet forest. The revegetation plan for this area is yet to be agreed with the current landowner. As a minimum, it will be returned to open woodland.
- Mt Fitch – a satellite site that is flat and requires minor works to improve and return to open woodland.
- Roads – these linear structures are likely to pass through many vegetation units and some roads may be required by future landowners to remain. The revegetation for a road will be specified once the road is nominated for revegetation.
- Borrow – FRALT – refers to the potential borrow pit south of Rum Jungle. Agreements for final closure of this landform have not yet been reached with the FRALT.
- Borrow – CCGC – refers to the potential borrow pit adjacent to Rum Jungle Creek South. Agreements for final closure of this landform have not yet been reached with the CCGC.

### 7.11.3. Data Collection

Several sources were accessed in development of the Ecological Rehabilitation Strategy. The primary data source relevant for the site is the detailed vegetation mapping that has been carried out by several parties over time. This work enables a thorough understanding of potentially analogous sites and provides a starting point to develop a modified revegetation strategy that meets the project objectives whilst being cognisant of the strongly-altered environmental conditions onsite. Additionally, data was collected from modern revegetation programs at McArthur River Mine, Ranger Mine and overseas examples. A literature review and review of data from onsite field trials also assisted to form the strategy and methodologies described in this chapter. Additional information from a literature review and overseas sites is located at Section 7.13.

***Baseline vegetation mapping***

Baseline mapping by Eco Logical in 2014 provides a detailed vegetation unit map and assessment of impacts to those vegetation units. Additionally, detailed species lists are provided for each unit.

In order to develop the Revegetation Strategy, the domain area objective was compared to surrounding residual vegetation units and appropriate target vegetation types and framework species were selected for each domain. Several vegetation units may bound a single domain and, in this case, the framework species were selected from across all of the adjacent units. This is likely to provide an improved chance of revegetation success. All species selected are endemic to the area.

In the case of the modified vegetation types, shallow rooted framework and coloniser species have been selected in the species list. This is to meet the objective of rapid vegetation establishment on the appropriate landforms.

A final data check over the species list is required to identify plants that are commonly used bush tucker plants. These are not to be included in domains where waste rock materials are to be stored. This modification to the species list also correlates with the three modified target vegetation types as shown in Table 7-1. These are modified systems to reduce risk posed by deeper rooted plants and bush tucker plants. The refinement of this list for purpose of bush tucker exclusion is best done in the field with Traditional Owners.

Pertinent maps from the baseline vegetation work by Eco Logical (2014) are presented in Figure 7-14 and Figure 7-15. Table 7-1 is to be read in conjunction with Figure 7-14 below as the vegetation unit numbers correlate to the descriptions within this Figure.

### *Riparian vegetation surveys*

Metcalfe (2002) carried out an overarching riparian vegetation survey along the East and West Branches, as have Hydrobiology (2013), in addition to the work listed above by Eco Logical (2014). Hydrobiology (2013) and Metcalfe (2002) agree that the main branch of the Finniss River differs in density and diversity of riparian species from the East Branch. This can be attributed to both the degradation due to historic mining practices and the ephemeral nature of the East Branch. Data collected from these surveys has informed the development of the species list for each domain.

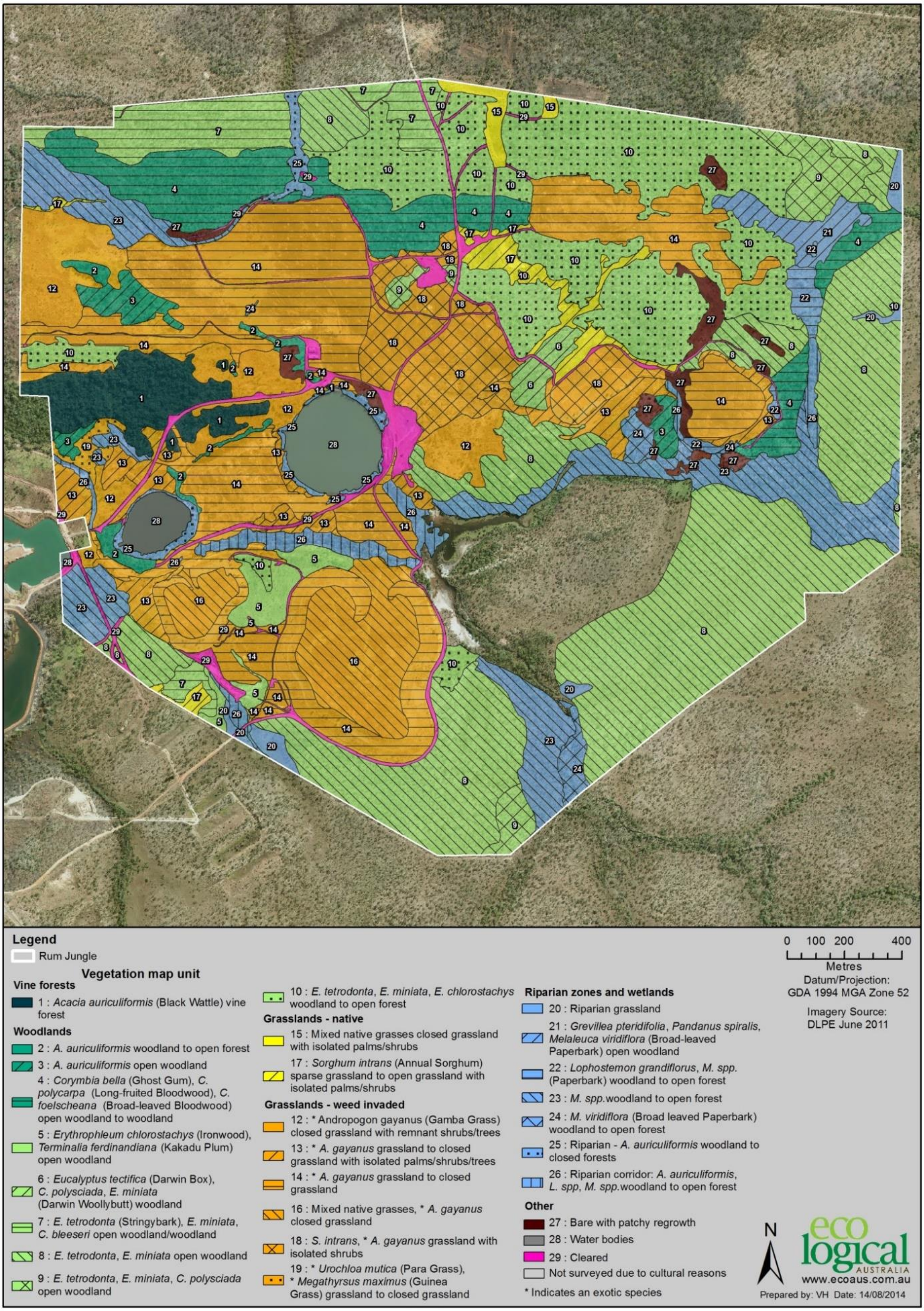


Figure 7-14: Vegetation units, Rum Jungle Mine

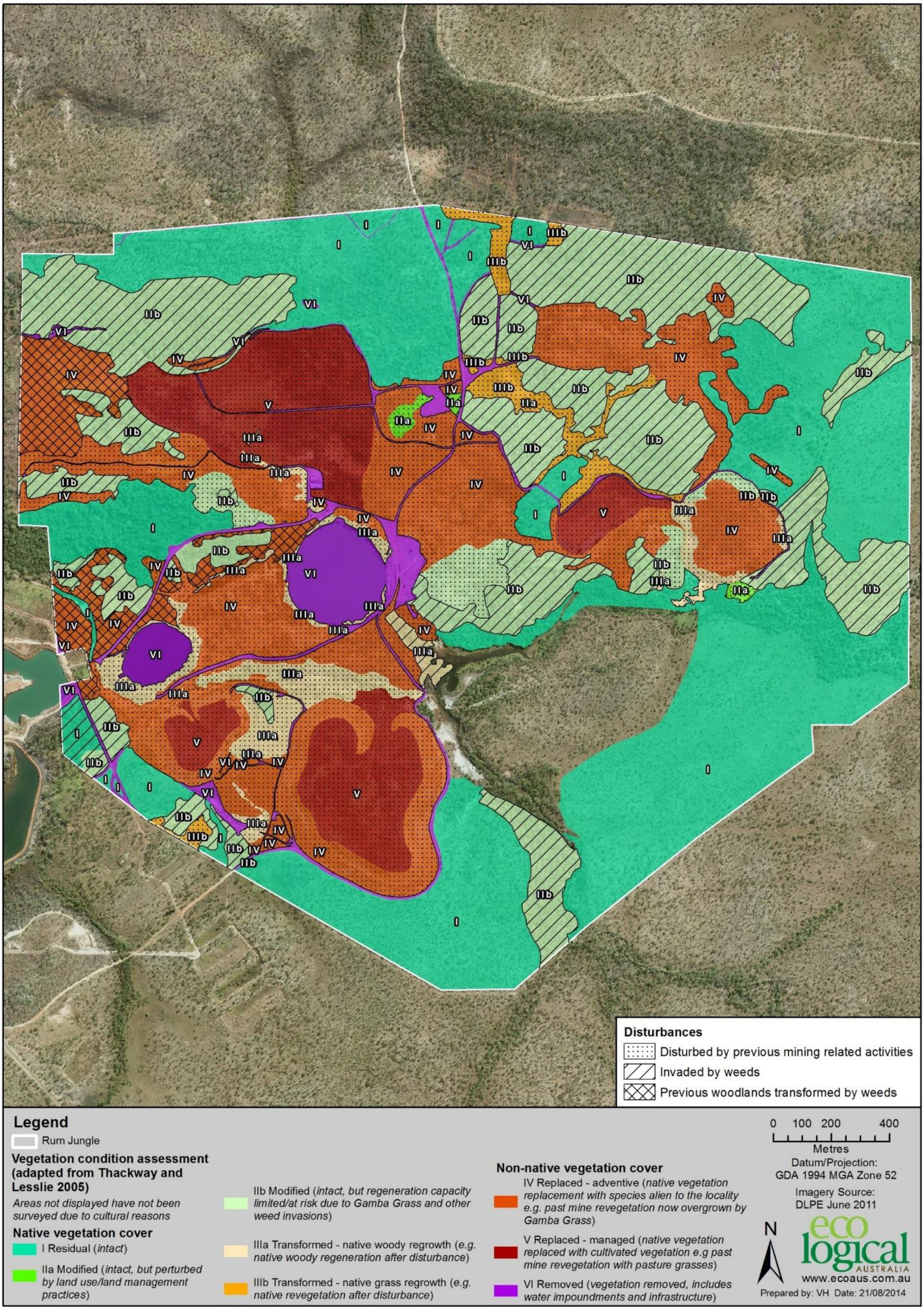


Figure 7-15: Vegetation condition and disturbances, Rum Jungle Mine

***Modern examples – Top End***

Several local mines provide an opportunity from which to learn in particular those that are also metalliferous or uranium sites. McArthur River Mine (C. Jones pers. comm.) recommend the following key points to consider:

- Local species collected from adjacent bushland provides sound revegetation results.
- Tube stock have been successfully utilised in diversion channel revegetation works.
- Use of Typhoon Native Fertiliser pellets in seedling plant out improves growth rates, especially in areas lacking natural nutrient cycling.
- Revegetation into subsoils can be achieved if improvements such as the addition of fertiliser, water crystals and organic matter or humus are added into the cultivated tube stock hole.
- Irrigation systems can be established to allow for year round planting and to make the best use of staff work patterns. Wet season planting may pose additional safety risks for staff.
- Diversion channel planting density is 2 trees and 4 grasses *per* square metre to aid erosion protection.
- Germination and growth rates are faster over September to March.
- Large woody debris, if correctly anchored, provides good habitat for aquatic species in watercourse reconstruction works.
- Hydromulching tends to inhibit seed germination of local tree species and, if used, should have low amounts of mulch. Hydroseeding has better performance.
- Drainage line restoration elements:
  - Hydraulics and erosion control strongly drive revegetation options.
  - Topsoil should not be wasted in high flow areas as other options are available.
  - Hydromulching was not particularly successful in the channel revegetation process.

Woodcutters Mine care and maintenance site, nearby to Rum Jungle, have the following observations regarding lessons learned in revegetation works:

- Darwin Cycads can be successfully transplanted as part of a major earthworks project.
- Local plant species are performing well within the revegetation system.
- Local employment has been generated by utilising a local Traditional Owner business to supply tube stock to the project.

A key paper by Lu and Meek (2019) on revegetation works at Ranger Uranium Mine provides important information pertaining to local conditions and methods. In summary these are:

- Revegetation as a two-stage approach where initial establishment of framework species is followed by a secondary planting of other species that are either unable to establish in harsh conditions or are a high risk of outcompeting framework species in initial establishment.
- Framework species (e.g. *Eucalyptus tetradonta* and *Eucalyptus miniata*) rely on below ground resources to survive fire disturbance. Seedlings must be protected from fire for at least five years.
- Different land surface types need different revegetation strategies.
- Maximise surface roughness to capture resources and create microhabitats.
- Utilise local resources such as seed provenances, soils and mychorrhizal fungi spores in nursery production processes has improved results. Nursery tube stock is recommended for establishment of framework species.
- Introducing strategic fertilising and watering can improve outcomes.
- Include non-aggressive local Acacias but not aggressive species as they rapidly outcompete framework species. Additionally, avoid competitive colonisers or fragile species such as grasses and mid-storey species until after the framework species are established.
- Threatening processes (weeds and fires) must be controlled during vegetation establishment and fire exclusion at least for the first 5-8 years.
- All work should be well monitored in order to improve strategy and understand performance of revegetated systems.

### ***Revegetation trial***

A revegetation trial on the Rum Jungle site was initiated by the then Department of Mines and Energy in 2012. The site of the trial was Borrow Area 5 in the north-east of the site. Borrow Area 5 contained buried sludge from the 1980s water treatment plant. It was initially revegetated between 1984-1985 with batter reshaping, floor ripping, top-soiling, limited drainage works and seeding with a mixture of grasses and legumes. Over time, Borrow Area 5 became dominated by Gamba Grass.

The aim of the revegetation trial was to grow a woodland of local native species. The method trialled was weed control and direct seeding. The trial began with weed eradication work, carried out over three years (2012 - 2014). The surface soil was then scarified prior to seeding. Rip lines were approximately 10 - 20 cm in depth, avoiding existing native vegetation. Seeding commenced as soon as possible after scarification using local native seed of 35 species collected during 2013 and 2014. The seed was mixed with coarse damp sand and spread by hand in early December 2014 followed by aerial application of superphosphate fertiliser. A proportion of seeds were sent to a laboratory for a germination trial.

Additionally, in an attempt to limit Gamba Grass invasion, an area was seeded with Silk Sorghum. Silk Sorghum has been used as a cover crop in mine rehabilitation in northern Australia including at Gove and in western Cape York. Sown thickly, Silk Sorghum will overgrow most weeds and, by using available soil nitrogen, will also reduce the likelihood of a major competition from weeds in the following season (Cameron, 2014). Perennial sorghum pastures decline and eventually die when soil nitrogen is depleted. In the NT this may take only one to two years (Cameron, 2014).

Thus far, monitoring of the site has only been undertaken in mid-February 2016, *i.e.* 14 months after the area was seeded (EcOz, 2016). The rehabilitation was therefore at an early stage of growth, somewhat limiting conclusions that can be drawn at this early stage. Nevertheless, a diversity of tree and shrub seedling species were present and there was a dense groundcover, dominated by native grasses in most areas. Future monitoring will improve the knowledge gained from this trial area.

Key findings were:

- Acacias were the dominant group making up 63% of tagged plants and recorded in all plots. The proportion of Eucalypts was 6%. Of the species other than Eucalypts and Acacia, 9 of the 17 species seeded were recorded. Ten species were seeded but not observed; some of these had very low weight of seed, whilst others had very low germination rate. Six species not part of the seed mix were recorded; mature plants of all these were growing within or close to the revegetation area.
- Although no grasses, except the Silk Sorghum trial area, were part of the seed mix for the area, grasses and other ground strata species were present across the entire area. Density of *Urochloa piligera*, *Chrysopogon fallax* and *Sorghum timorense* was very high in some locations. However, some Eucalypts were growing in densely grassed areas and it was surmised that given numerous seedlings are present and appear healthy, and assuming that climatic conditions stay favourable, it seems likely they will emerge from the ground strata in the next few years.
- Of the Eucalypts present, only *E. miniata* was common (it was also the most common seed by weight in the seed mix). There was a very low density of the key species *E. tetrodonta*; however, this species had a relatively low germination rate from the laboratory trial.
- Only one *Melaleuca* plant was recorded, although two survey sites appear to be suitable habitat as they are low lying and are seasonally-waterlogged. The low density of *Melaleuca* appears to be related to poor seed, as seed did not germinate in the laboratory trial.
- The Silk Sorghum cover crop had grown densely, but had not completely excluded Gamba Grass. Without greater replication and investigation of other factors, it is not possible to determine if the Silk Sorghum is hindering the growth of Gamba Grass. The Silk Sorghum does not appear to be hindering the establishment of native trees and shrubs, with seedling numbers within the range of other sites and Eucalypts present in the two trial plots. Monitoring of these plots over the next couple of years will tell if the Silk Sorghum dies out and has influenced the growth and composition of the vegetation.

It was noted that the reconstructed landscape proposed for Rum Jungle will have a variety of landscapes and that these findings will not be applicable to all areas.

## 7.11.4. Fauna

The most significant threatening processes on the Rum Jungle site for the restoration of fauna are:

- heavily-disturbed land with poor revegetation outcomes to date which provides few resources for fauna;
- Gamba Grass and its role as an ecosystem fire modifier; and
- feral animal impacts particularly pigs, cattle, cats and cane toads.

As such, weed and feral animal management plans will play a strong role in the fauna restoration process. In order to provide sufficient resources to support fauna restoration, a critical element of the rehabilitation strategy for Rum Jungle is the inclusion of additional structural elements into the work program alongside revegetation practices. At present, the heavily disturbed site is surrounded by varying habitat quality; however, the rehabilitation program aims to encourage progressive fauna utilisation of newly revegetated areas.

***Fauna elements***

Building on practical experience from the two sub-Saharan sites mentioned above, a review of available information pertaining to fauna restoration for the site was carried out. The Australian Government's National Recovery Plans for the Threatened Species (DoE, 2019) identified for the project area provided a starting point for locally relevant information. Additionally, *The Action Plan for Australian Mammals 2012* (Woinarski *et al.*, 2014) provides ecology information for these species.

Review of these sources reveals several physical elements that could be incorporated into the restoration plan for site to increase diversity of niches and provide shelter within the habitat. Apart from the mitigation of impacts by fire, weeds and ferals, these elements can be summarised as:

- Rocky Mounds – Quolls and other species utilise rocky mounds as dens. Rocky mounds are known to provide perching positions for birds in Tanzania and Mali.
- Hollows on Ground – Mammals and others utilise hollows for shelter or nesting.
- Pandanus Stands – Black-footed Tree-rats may use as dens.
- Large Woody Debris – aquatic species utilise as reported at McArthur River Mine.

Resources for these elements are to be recycled within the work program. These elements will be placed within newly rehabilitated areas as far as available resources will allow. Monitoring fauna utilisation is not planned as a formal monitoring parameter for rehabilitation metrics though it may provide an opportunity for research by external organisations.

## 7.11.5. Resource Reuse and Salvaging

Resource reuse and salvaging is critical to successful rehabilitation processes. The Darwin Cycad is a culturally-significant plant and a relocation plan has been developed (see Chapter 14 – Terrestrial Flora and Fauna) to ensure that individuals are salvaged and replanted into non-impacted areas and into new revegetation spaces. Cycad replanting will occur throughout all stages of the earthworks program. Additional resource reuse and recycling measures include salvaging of any timber or vegetation that cannot be preserved during the earthworks program and clean rocky oversize that cannot be used in rock armouring.

## 7.11.6. Domain-based Methodology

This section presents the general methodology that will be tested for revegetation practices for each domain. Generally, the domains can be grouped according to their functionality – Ecological Restoration or Stabilisation as shown in Table 7-1. Restoration domains have very few modifications required to the surrounding species lists, however Stabilisation domains have modifications due to the domain containing the WSF or Dyson's Pit backfilled.

Topsoil resources are expected to be insufficient for the task at hand and will need to be used judiciously. For all areas, all efforts must be made to exclude fire for at least five years or until the secondary planted species are at low risk of impact from fire. Prior weed elimination must be given significant effort because the greatest risk to the rehabilitation program is invasion by Gamba Grass and subsequent competition and modified fire regime. Chapter 14 – Terrestrial Flora and Fauna elaborates on this.

The majority of seed stock is to be harvested from surrounding FRALT land to ensure local provenance is utilised as they are adapted to local conditions. If required, additional seed stock may be collected farther afield though this should be avoided if possible. Nursery practices, including the use of local soils and mycorrhizal fungi spores, will need to be explored and developed.

The two-stage planting approach as recommended by Lu and Meek (2019) is to be adopted at Rum Jungle to improve the likelihood of successful framework species establishment. The final two-stage species list should be developed following the guidance of lessons learned from the Ranger Mine revegetation works (see above).

### *Ecological Restoration domains*

- Priority is to initially establish framework species and reduce competition by colonising species. Full topsoil is not required for these large areas as it is likely to encourage Gamba Grass and other colonising species.
- These areas are generally flat and contour ripping is recommended to enhance resource capture and establishment of microhabitats conducive to seedling establishment.
- Onset of Wet season confirm soil moisture is sufficient.
- Spray or slash germinated competitive species (if present).
- Cultivate plant holes at 2x3 m grid spacing.
- Introduce inoculation of topsoil and organic matter for symbiotic microbiota.
- Include a Typhoon Native Fertiliser tablet.
- Plant tube stock or direct seed into cultivated holes *per* domain species list in Table 7-1.
- Monitor for germination rates if direct seeding or survival rates if tube stock.
- Remove competitive species from framework species.
- Include fauna elements as far as resources are available.

Alternative methodologies to be trialled include Wet season propagation and Dry season planting requiring irrigation.

After 3-4 years of vegetation establishment, a second stage of planting can be instigated whereby sensitive or potentially competitive mid-storey and groundcover species can be introduced into the revegetation system.

### *Stabilisation domains*

- Introduce topsoil to slope to introduce seedbank of grasses and coloniser species.
- Hydroseed onto newly-formed surfaces as *per* domain species list (Table 7-1).
- Monitor for germination rates and bare patches; on batters monitor for erosion.
- Weed control of any Gamba Grass or other pest species well before the onset of seeding and while the plants are small enough to easily control.

Alternative methodologies to be trialled include tube stock supplements to assist in establishment of framework understorey species. Seed mix for the active revegetation is to be made up of framework under- and mid-storey species as listed in the domain table at Table 7-1.

After 3-4 years of vegetation establishment, a second stage of planting can be instigated whereby sensitive or potentially competitive mid-storey and groundcover species can be introduced into the revegetation system.

### *Old Tailings Dam*

The Old Tailings Dam area is earmarked as a starting point for the establishment of revegetation systems for site. The area requires no further bulk earthworks; however, a final check of phytotoxic elements (predominantly copper and soil pH) will aid in development of a Soil Amelioration Plan if it is deemed required. There may be residual patches of copper or low pH soils in the area resulting from historic practices that may need to be addressed prior to the establishment of revegetation practices.

Surface roughness needs to be greatly improved over this area as there is very little surface texture to encourage infiltration, microniches and resource capture. Resource depletion is a significant issue on this site as frequent fires and high runoff coefficients are hindrances.

# 7.12. Rehabilitation Strategy Success

The key indicators of a successful rehabilitation strategy at Rum Jungle are directly related to the key project objectives. Cognisant of the abovementioned restoration objective, and the challenges that legacy issues pose at this site, revegetation is best served by a monitoring program that is designed to:

- Indicate triggers for action to repair or remediate a site.
- Commence the development of a dataset to track long-term development and performance trends for the established ecological systems.

The monitoring program for the Revegetation Strategy will focus initially on nursery production parameters, seedling survival rates and monitoring of threatening processes (weeds and fire). As the vegetation systems develop, a more comprehensive set of indicator parameters can be monitored. This is likely to include:

- Flora surveys to include species presence, diversity, canopy cover, densities, groundcover and development of these over time.
- Landscape functionality indicators and the development of these over time such as stability, infiltration, nutrient cycling and litter class. (Tongway and Hindley, 2005).

These parameters will form the foundation for future development of a body of evidence for proof of environmental health.

## 7.12.1. Rehabilitation Success Metrics

The Rehabilitation Strategy outlined in this chapter is aimed at providing an overview of the actions required to remediate the site conditions and to commence the restoration of ecological processes across the project area. These actions are planned around delivery of the key objectives of EBFR quality improvements and advancement of the ecological restoration processes for site including mitigation measures for threatening processs. This includes specified actions as requested by Traditional Owners. The Stage 3 Rehabilitation Project is a step within a longer term set of steps that are directed towards improving the chance of resolution of the outstanding land claim for the site. After Stage 3 is complete, a longer term monitoring phase is anticipated that will allow time for ecological processes to develop and the site to draw closer to a self-sustaining, non-polluting condition. Achievement of this state will be demonstrated through the rehabilitation success metrics that demonstrate fulfilment of each closure objective.

The Proponent considers that the use of completion criteria for Stage 3 works is not applicable as at that point, change in title or tenure is not planned or anticipated. Traditionally, completion criteria are tools for determining if a mineral title can be relinquished and this does not apply here. At the transition from Stage 4 to Stage 5 there may be a requirement for environmental health criteria to support the transition to the Land Use Plan and perhaps the resolution of the outstanding land claim. This is a matter for both governments, Traditional Owners and the Northern Land Council in future.

As such, rehabilitation success metrics, described in Table 7-2, have been developed for the key rehabilitation elements described in this chapter. These metrics will be monitored over the Stage 3 works as the preliminary monitoring tool for potential future completion criteria and appropriate mitigation response measures will be developed as the project progresses. Industry standard methodologies will be employed for implementation of the monitoring plans.

Reporting against these metrics for Stage 3 will be required internally between the Commonwealth and NT Governments as part of any National Partnership arrangement should the project be funded by the Commonweatlh. Additionally, water quality parameters are likely to require reporting as part of the WDL. The Proponent's existing record keeping systems include electronic and hard copy filing systems, electronic databases for key documentation and the use of ESDAT for environmental quality monitoring data storage. The Proponent will utilise existing systems for long term record and data capture and may be required to uprade existing systems to accommodate this project.

A detailled monitoring plan for rehabilitation success metrics will be developed in the event that project funding is approved and a National Partnership arrangement is negotiated for delivery of Stage 3 works.

Table 7-2: Rehabilitation success metrics

| Rehabilitation Strategy Element | Objective | Target | Additional Information |
|---|---|---|---|
| Cultural | Preserve Aboriginal places and objects | All places and objects managed as *per* the CHMP | Chapter 8 |
| Radiological Hazard | Health of potential future land users not impacted by radiological soils | Dose assessment for site is reduced to below 10 mS/yr by completing the Excavation Plan | Chapter 16 |
| | | An end of Stage 3 hazard assessment will inform the completion of a finalised Land Use Plan | Chapter 16 |
| Asbestos and Scrap | Health of future land users not impacted by asbestos and scrap | Contain and isolate asbestos and scrap wastes from surface within a new WSF within the project area | Chapters 6 and 7 |
| Waste Rock, Copper Soils and Groundwater | Surface water quality in Zone 2 meets species protection level as detailed by Hydrobiology | Surface water quality meets LDWQOs | Chapter 10 |
| | Waste rock and copper contaminated soils are isolated from human receptors | Excavation depth for copper contaminated soils is 2 m in locations where the unsaturated zone copper concentrations are higher than HIL-D | Chapter 6 |
| | | A 2.5 m cover is placed over the WSF | Chapter 6 |
| EBFR Realignment | EBFR flow path is as close as achievable to original EBFR water course | Return maximum safest flow volume through a reconstructed EBFR water course | Chapter 11 |
| Ecological Rehabilitation | Return living systems to riparian zones | Revegetation for riparian zones is complete | Chapter 6 |
| | Seed stock provenance is local | 80% of seed is collected from FRALT | Chapter 6 |
| | Revegetation trends positively | Framework species established in Ecological Restoration domains | Chapter 6 |
| | | Ground and understorey species established in Stabilisation domains | Chapter 6 |
| | Fauna restoration | Structures are included into domains | Chapter 6 |
| Landforms | Landforms are safe, stable and not contributing additional heavy metal load to EBFR | Construction of new landforms as *per* engineering specification | Chapter 7 |
| | | Erosion processes are self-stabilising | Chapters 7 and 9 |
| | | Vegetation systems are shallow rooted < 2.5 m | Chapter 7 |
| | | Active feral animal management is carried out over the life of the Stage 3 works | Chapter 7 |
| Threatening Processes | Bushfire and weeds are not causing detriment to landform stability or water quality | Bushfire excluded from revegetation until five years of age | Chapter 14 |
| | | Weed management requirements onsite is not significantly different to surrounding FRALT | Chapter 14 |

# 7.13. Additional Data Sources and Examples

***Modern examples – Two gold mines in sub-Saharan Africa***

This development of this strategy has been informed by practical experience within the Rum Jungle project team gained from rehabilitation systems overseas in similar monsoonal environments in sub-Saharan Africa. Notwithstanding differences in social and environmental factors, the methodologies developed and refined over many years on these sites has proven successful and key elements apply to the Rum Jungle site. The ecological rehabilitation at these two sites included key learnings such as:

1. The key factor in revegetation failure on these sites tended to be a lack of soil moisture holding capacity due to the prolonged Dry season. Revegetation in thin topsoil over broken fresh rock invariably failed on all trial surfaces. Hot surface conditions and lack of available moisture caused high seedling mortality rates and revegetated surfaces lacking in diversity.
2. A minimum thickness of 2 m of weathered cover over porous rocky media gave strong revegetation results. This cover provided the key function of Dry season water holding capacity to allow plants to access this water source.
3. Lack of topsoil is not necessarily a limitation to successful revegetation. Revegetation trials in subsoils and in oxidised waste rock gave rise to suitable revegetation. The microbiological activity of the local areas (due to climate) probably improved the performance of subsoils and oxidised waste rock media. Inoculation from tube stock soils probably helped, but this was not studied with rigour.
4. Grasses and colonisers rapidly outcompete framework species if not actively managed.
5. Grasses provided excellent erosion stability, however presented a significant wildfire risk to newly establishing surfaces. Fire risk rapidly decreased after a revegetation age of four years.
6. Revegetation success was strongly linked to eliminating fire and competition from colonisers. These ecosystems are not fire-dependant.
7. Fresh topsoil provided best results and rapid establishment. Progressive topsoil stripping in sequence with revegetation allowed for topsoil to be stripped, loaded, hauled and placed immediately. Elimination of topsoil stockpiling gave significant result advantages.
8. Topsoil should be stripped in new areas together with subsoils. Criteria for ‘rehabilitation media’ on these sites was an approximate depth of 0.5 m which correlated to grass root penetration depth. The mixing of organic layers with soils and subsoils down to this depth proved more efficient that trying to strip true topsoil from subsoil.
9. Any vegetation removed from an area is a valuable rehabilitation media. Large logs and trunks when stockpiled onto newly rehabilitated surfaces provided a rapid fauna habitat. Typically, local bird species would occupy these vegetation piles when grasses were seeding and additional seed load was imported by birds. The vegetation piles also provided longer term shelter habitat for ground dwellers such as reptiles and mammals.
10. Large rocky mounds when stockpiled onto newly rehabilitated surfaces provided rapid fauna habitat. Similar to large woody debris piles, these provided a place for bird perching and for shelter for mammals and reptiles.
11. Fauna species would utilise newly revegetated surfaces almost immediately though any trends were strongly dependant on structural elements and large mammal utilisation information was purely opportunistic rather than studied with any rigour. Primarily the sequence of use followed the path of: bird and reptile temporary utilisation for opportunistic foraging over the first year → bird, reptile and mammal utilisation for breeding after the fourth year → larger mammals forming permanent occupation (*i.e.* Jackal dens) after 8-9 years.
12. Weeds, including woody weeds, needed to be managed immediately after revegetation began. Manual work to remove weeds was often the only viable method as overspray of herbicide was fatal to newly planted tube stock.
13. Planting holes were cultivated 0.5-0.6 m holes dished to catch water and encourage infiltration. No fertiliser was necessary. Tube stock was planted at the start of the Wet season when soil moisture conditions were correct. Infrequently tube stock would need to be watered if rain patterns were unreliable. After the first year, generally survival rates were 80-90% in properly prepared and maintained areas.
14. Fauna restoration was improved by large woody debris piles and large rocky mounds. Also, excluding people, vehicles and cattle from all revegetation areas improved results.

15. The use of tube stock provided superior results as long as they could be watered if need be once in the field. This was required infrequently. Nursery procedures were refined over time and included seed harvesting from nearby sources, seed storage and treatment procedures, potting processes utilising local soil resources, sowing and weeding timelines, hardening off, plant out timeframes and data capturing. The continual improvement of processes was informed through experience and data collection.
16. Tube stock planting density of 2x3 m grid provided sufficient density at these survival rates if the area was protected from fire, cattle, vehicles and other impacts.
17. Contour ripping on waste dump embankments worked well to create microclimates and encourage revegetation substrate moisture condition. If performed correctly, ripping provided a good control to gully erosion. This methodology must only be employed when upstream berm and plateau catchments are directed away from the batter slopes. Utilising ripping on the top half of slopes also worked well in high intensity rainfall events.
18. Work cycles matched the season with Wet season planting successful. This may be challenging in the Rum Jungle context.

It is evident that some of the lessons learned through this experience can be trialled and tested within the context of Rum Jungle.

***Northern Australia literature review – revegetation***

Some key experiences of rehabilitation at other mines across northern NT and far north Queensland are presented below. It is important to note that significant advancements have been made in revegetation strategies in monsoonal environments since the publication of this literature, however they provide valuable baseline information:

- **Grasses.** In some instances, perennial grass or legume monocultures have resisted successional change (Luken, 1990). In an experiment aimed at quantifying the effect of grass competition on the establishment of native species at Weipa, Foster and Dahl (1990) detailed an inverse relationship whereby reducing native grass competition was found to dramatically increase native seedling survival. At Pine Creek, Fawcett (1995) found that where couch grass had established from the topsoil seed bank, native seedling mortality was 100%. An assessment of the success of Energy Resources of Australia's revegetation of the Jabiru East area by Lane (1996), found the dense cover of introduced grasses and legumes, which comprised the original seed mix, suppressed the establishment of the preferred native woody and herbaceous species.
- The use of **cover crops** has had mixed success in the Top-End. At Gove, mine sites where Rhodes Grass was used as a cover crop, was considered a success and shown to fade out of the system after approximately five years due to competition by recolonising native flora and reduced nutrient availability after cessation of fertiliser application (Hinz, 1981). In contrast, cover crops are no longer incorporated into seed mixes at Pine Creek after Fawcett (1995) found that they outcompeted tree seedlings for moisture and resulted in an increased fire fuel load. More recent work at Gove indicates similar findings as that presented by Fawcett (1995).
- **Acacias.** A high proportion of *Acacia* seedlings are commonly used for rehabilitation of disturbed areas. Acacias can have a positive impact in early rehabilitation through nitrogen fixing, protecting soil from erosion, contributing leaf litter to support nutrient cycling and breaking up the soil. There is some contention and a range of experience with the dominance of *Acacia* in early rehabilitation; as structural or competitive dominance in a community can prevent the ascendancy of later intermediate stage species (*e.g.* Connell and Slatyer 1977). On disturbed sites in Kakadu National Park, the dominance of early intermediate stage species, such as Acacias, has been observed to effectively stagnate successional development with recruitment of Eucalypts and other species to these systems being poor (Setterfield *et al.*, 1993). At a Pine Creek gold mine, early rehabilitation resulted in an *Acacia*-dominated community, whilst later seeding without *Acacia* seeds (although they were present in the topsoil) resulted in the establishment of Eucalypt-dominated communities (Fawcett, 1995). In contrast, at Alcan, in Gove, Hinz (1992) found recruitment of Eucalypts and other genera was more successful after the establishment of pioneering Acacias.
- A seed mix trial at Ranger Mine resulted in Cramb *et al.* (1997) recommending that Acacias be limited to less than 16% by weight (compared to 25% in this trial). At Gove, the Eucalypt to *Acacia* ratio is 8: 3.2 (Hinz, 1992).
- **Eucalypts.** Hinz (1997) believes the growth of *E. tetrodonta* in rehabilitation is dependent on an effective association with mycorrhizal fungi (*Nothocastoreum cretaceum*) and Reddell and Milnes (1992) reported that mycorrhizal fungi (and nitrogen-fixing rhizobia) were ubiquitous components of the soil biota in undisturbed soils of Kakadu National Park. The importance of re-establishing indigenous symbiotic microorganisms in mined soils in the tropics is widely accepted (*e.g.* Malajczuk *et al.* 1994, Ragupathy *et al.* 1997). Inoculation or the strategic use of fresh topsoil may increase numbers of this species. Given a low volume of topsoil

compared to the area to be rehabilitated across Rum Jungle, careful consideration should be given to its best use. Bell (1993) suggests that on WRDs a layer of topsoil showing no major physical or chemical limitations to root growth (such as alkalinity, sodicity or acidity) as thin as 50 mm will help vegetation to establish.

- Introduction of **tube stock** is an option to attempt to increase numbers of other Eucalypts. However, rehabilitation experience at Nabarlek Mine indicates that the performance of direct seeded revegetation is superior to that of tube stock planted areas (Hinz, 1990). In addition to the lower cost and the ability to cover large areas in a short space of time, plants grown from seed were generally more healthy and robust. Similarly, at a Pine Creek mine, direct seeded plants displayed superior growth rates compared with tube stock (Fawcett, 1995). Both Fawcett (1995) and Queensland Mines Ltd (1990) reported a 'stagnation' of tube stock shoot growth after planting. At Gove, Hinz (1992) found direct seeded plants developed a stronger root system than tube stock and the plants adapted to local conditions more rapidly and subsequently proved more sustainable. In contrast, Reddell and Hopkins (1995) found that tube stock revegetation trials at Ranger Mine had consistently outperformed direct seeded trials. This again highlights the site specific nature of rehabilitation.

## 7.14. References


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