03

Project description

3. Project description

3.1 Introduction

A detailed description of the proposed project / proposed action is provided in this chapter. The project detail is preliminary/concept design only at this stage, for the purposes of assessment in the EIS. Detailed design of project components and site surveys will be undertaken where relevant at a later stage, post environmental approval and Arafura's decision to proceed with the project.

Information in this chapter has been provided by Arafura. Other key sources of information include studies undertaken by specialist companies engaged by Arafura.

The chapter addresses a majority of Section 3 of the TOR.

3.2 Key project components

Arafura plans to mine, concentrate and chemically process REs at the Nolans site (Figure 3-1) then transport a RE intermediate product to an offshore refinery (separation plant) for final processing into high-value RE products.

Life of mine (LOM) production scheduling has been developed for a period of 43 years (Table 3-1). The project is being designed to produce 20,000 tonnes per annum of RE products.

Table 3-1 Nolans Project

Description	Unit	M&I Case[1]	LOM Case[2]
Pit Stages	Number	6	7
Total Mine Life	Years	25	43
Pre-production Period	Years	2	2
Effective Mine Production Period	Years	23	41

Note 1: M&I refers to the higher-confidence Measured and Indicated classifications of the project's total inventory of Mineral Resources that, under certain assumptions, could be converted to economic Ore Reserves in accordance with the 2012 JORC Code.

Note 2: LOM refers to the project's total inventory of Mineral Resources, represented by Measured, Indicated and Inferred classifications in accordance with the 2012 JORC Code.

The general arrangement of the proposed operation includes the three key sites, the mine site, the processing site and the borefield. In addition, the workers' accommodation village, utilities corridors and access roads comprise Nolans site. A more detailed inventory of key project infrastructure is provided below.

3.2.1 Mine site

An open pit will be excavated to a depth of 225 m with a surface area of up to 135 ha. Associated infrastructure includes the following:

- Six waste rock dumps will receive a LOM waste quantity of 158 million loose cubic metres (mlcm) constructed to a height of about 50 m in 10 m lifts interspersed with 5 m wide berms
- Topsoil storage with a footprint of 95 ha and height of about three metres
- Stockpile areas
- Run-of-mine (ROM) pad to provide a facility for selective mining and ore blending (up to three months' ore supply)

- Concentrator comprising a comminution circuit to crush and grind the ore, and beneficiation circuits to reject gangue (valueless rock or mineral aggregates in an ore) and produce a mineral concentrate
- Flotation tailings storage facility (TSF) comprising LOM envelope of 245 ha and an embankment height of around 25 m
- Heavy and light vehicle workshop and administration offices and facilities comprising wash down area, tyre change facility, lube storage facility, etc.
- Haul roads
- Kerosene Camp Creek diversion and
- A single pumping stage slurry pipeline between the concentrator and processing plant.

The open pit is designed to a depth of 225 m below ground level and is expected to require dewatering to on-site turkey's nest dam. Overburden and waste material will be deposited in purpose constructed waste rock dumps (WRDs) with a stand-off distance from the pit of 50 m. Ore will be processed through the concentrator to produce a mineral concentrate and tailings.

Mining operations will deliver broken ore to various stockpiles on the ROM pad from which a front end loader will feed the crushing circuit. A single stage jaw crusher, with dust suppression, will crush the rock to around 50 mm. This crushed material will then be fed to a ball mill for grinding before it is pumped to a beneficiation circuit comprising high intensity magnetic separation and flotation cells to produce a mineral concentrate.

The concentrate is then pumped via a bunded HDPE slurry pipeline to the processing site located eight kilometres south of the mine site.

Figure 3-1 illustrates the general arrangement of the central mining and haul road network.

3.2.2 Processing site

The processing plant will require construction of the following infrastructure to produce RE intermediate products:

- Extraction processing units
- Sulfuric acid plant
- Process residue storage facilities (RSFs) to store phosphate, impurity and water leach residues in cells, with a combined potential footprint area of 160 ha and embankment heights of up to 24 m
- Evaporation ponds consisting of six cells x 10 ha each and an embankment height of 2.5 m
- 18.5 MW gas fired power station.

The processing plant will produce a number of waste streams and two RE intermediate products. Waste streams will be confined to onsite engineered storage facilities.

Figure 3-2 depicts the processing site general arrangement.

3.2.3 Borefield

Groundwater will be supplied from multiple bores located northeast of Reaphook Hills and pumped to a centrally located transfer water pond for onward pumping to a reverse osmosis (RO) plant for use in the processing plant.

Infrastructure in support of the borefields will comprise:

- Well heads, pumping stations and above ground water transfer pipelines
- Minor service roads and power supply.

Figure 3-3 depicts the borefield general arrangement.

3.2.4 Access and haul roads

Access roads/tracks and service corridors will be established for the following:

- From the Stuart Highway (intersection with Stuart Highway approximately five kilometres south of the Aileron Roadhouse access road) to the processing site
- Between the processing site and the mine site
- From the processing site to the accommodation village
- From the processing site to the borefield area via an access track and services corridor.

The main access road from the Stuart Highway to the processing site will be built to a public road standard with a pavement width suitable for the safe passing and overtaking of heavy vehicles (i.e. road trains). This will be a sealed road with signage, road markings, etc. also suitable for anticipated occasional public use.

The internal road between the processing site and the mine site will be gravel because traffic volumes will be relatively low. The road will be engineered and maintained by internal road maintenance crews.

Other project roads, including those to the borefield, will likely be of a lesser quality but all will be constructed to ensure user safety as a guiding principle.

Road construction will adopt methods aimed at avoiding changes to surface water flow, through construction of floodways and/or culverts and/or installation of side drains where necessary. Baseline biodiversity data will be used during the road design to avoid impact to sensitive areas (e.g. creek crossings) where possible.

Wherever practicable, services including power, water, sewerage and communication will run within the access road corridors. This will enable regular inspection of infrastructure by site personnel. It is intended that wherever practical, natural drainage will be allowed to flow under or across roads with minimal impediment to ensure the natural flow of surface water.

Flora, fauna and heritage surveys of the proposed corridors for all internal roads (and utility corridors) have been undertaken. An allowance of a 100 m wide corridor for the sealed access road between the Stuart Highway and the processing site, and 30 m wide for all other access roads, was made. The wide corridor assessment allows flexibility in alignment of the road and temporary construction laydown areas. The final road alignment will be significantly less than the surveyed corridor.

The road corridors have been selected to avoid heritage sites and sensitive vegetation.

3.2.5 Other infrastructure

Other infrastructure proposed to be constructed for the project includes:

- Accommodation village (Figure 3-4)
- Water treatment plant - a small packaged unit located within the processing site
- Sewerage treatment plants – small package treatment units at each of the processing site, mine site and accommodation village
- Site wide drainage and sediment basins
- Gas supply offtake pipeline (to connect to the existing Amadeus Basin to Darwin, high pressure gas pipeline)
  - Above ground pipelines that will be generally aligned with road access corridors, to enable regular inspection and access when required. Pipelines include:Potable water supply pipeline (from the borefield area to the mine site, processing site and accommodation village)
  - Process water supply pipeline (from the borefield area to the processing site and mine site)
  - Slurry transfer pipeline (HDPE pipeline earth bunded along the pipeline corridor with deflection shield on welded joints to minimise impact of welding failures) from the concentrator at the mine site to the processing site as mentioned above in Section 3.2.1).
- Overhead power lines (from the power station at the processing site to the mine site and accommodation village)
- Fuel and materials storage facilities at the mine site, processing site and accommodation village. It is likely there will be three fuel storages, the largest of which will be at the mine to provide fuel for the mining fleet. Smaller storages will be built at the processing site and at the accommodation village for backup power.

Additionally, the project will include offsite components as detailed below.

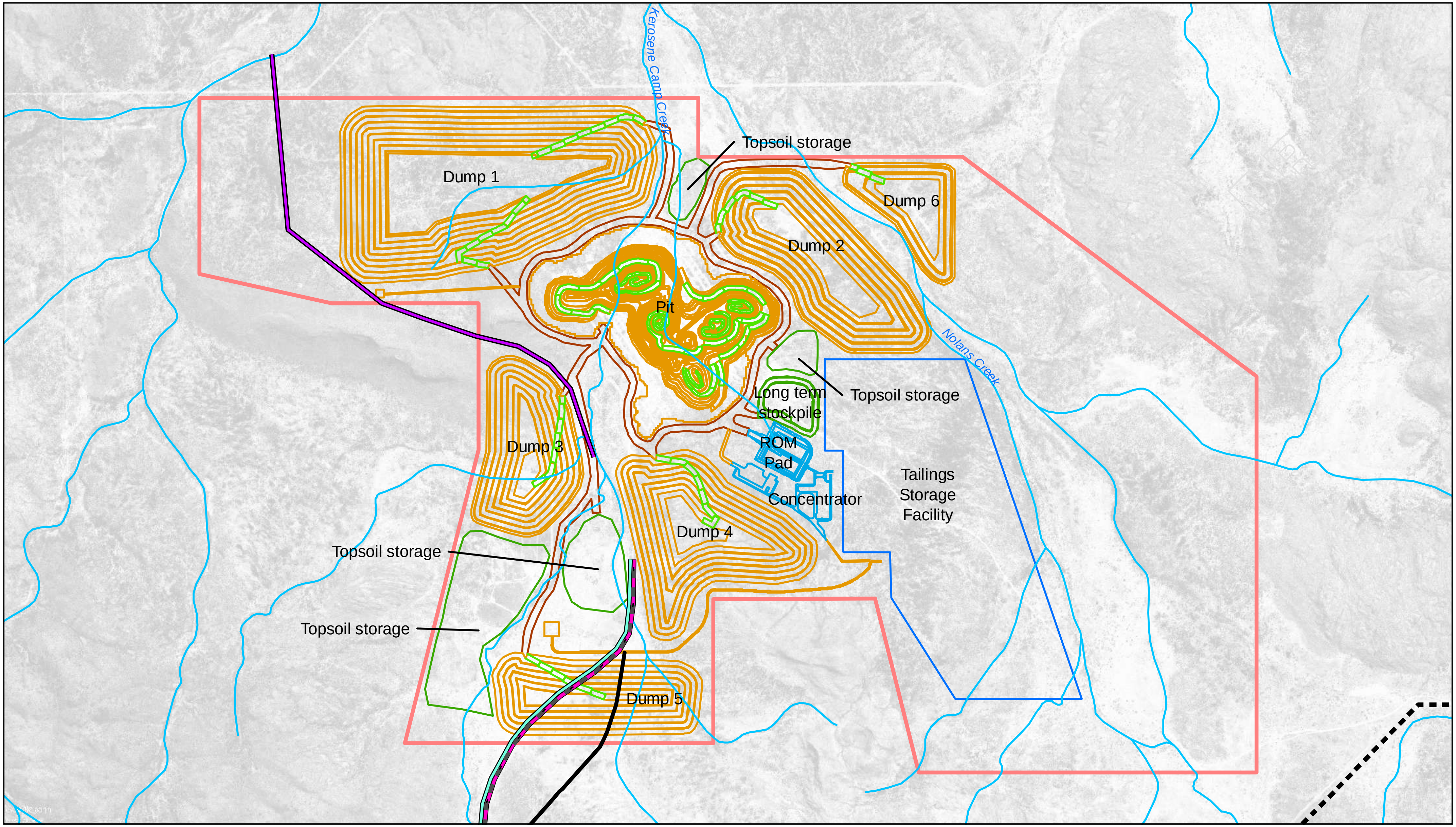
3.2.6 Logistics

Arafura is intending to work with the owners and operators of existing freight facilities in Alice Springs and Darwin to ensure those facilities meet the logistics requirements of in and outbound reagents, materials and product volumes. The main material storage facility at the processing site will be sized to store and manage in and outbound shipping and tank containers that meet the International Organisation for Standardisation (ISO) requirements.

3.2.7 Separation plant

A separation plant will be constructed within an established chemical precinct at an offshore location (at this stage assumed to be the USA Gulf Coast although other locations with similar logistical advantages, such as South Korea, are under consideration). The RE intermediate feed to the separation plant will be separated into three final RE products using solvent extraction followed by precipitation and calcination.

The separation plant will be subject to a separate approvals process and is excluded from the scope of this EIS.



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0 250 500 750 1,000

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Powerline
- Potable Water Pipeline
- Diversion Channel
- Water Supply Pipeline
- Waterways
- Access Road
- Existing Gas Pipeline
- Mine Site Boundary

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Environmental Impact Statement

Job Number | 4322301
Revision | 0
Date | 18 May 2016

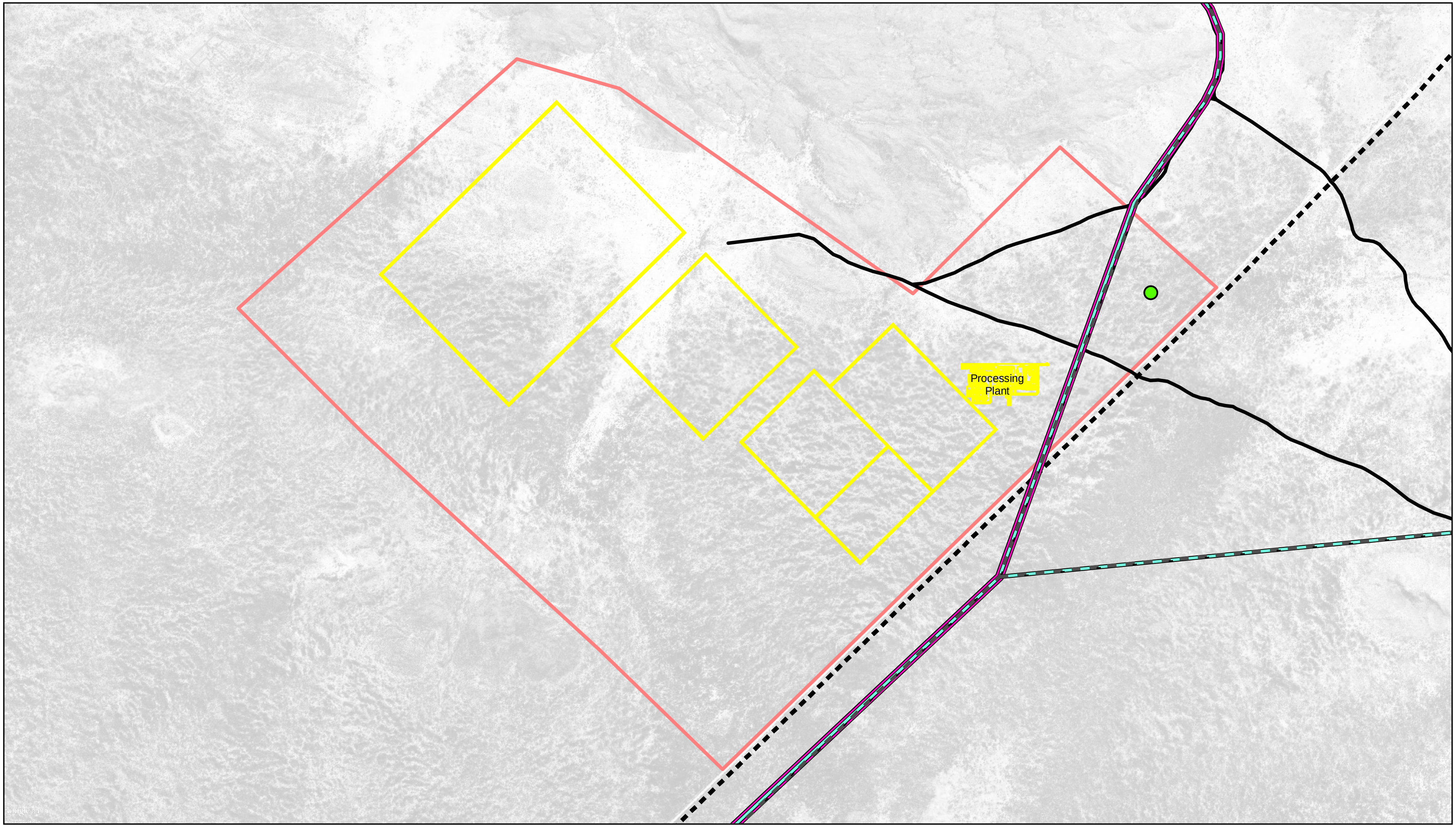
Mine site general arrangement

Figure 3-1

G:\43\22301\GIS\Maps\4322301_011_ProjectInfrastructureMineSite.mxd

Level 5 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: Google Earth Pro - Imagery (Date extracted: 29/04/2015). ARL - Proposed Pipelines, Proposed Mine Site, Proposed Diversion Channel Options, Tailings Storage Facility (2015). Created by: CM



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Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Power Station
- Residue storage facilities (RSFs) and evaporation ponds
- Powerline
- Potable Water Pipeline
- Water Supply Pipeline
- Existing Gas Pipeline
- Access Road
- Processing Site Boundary

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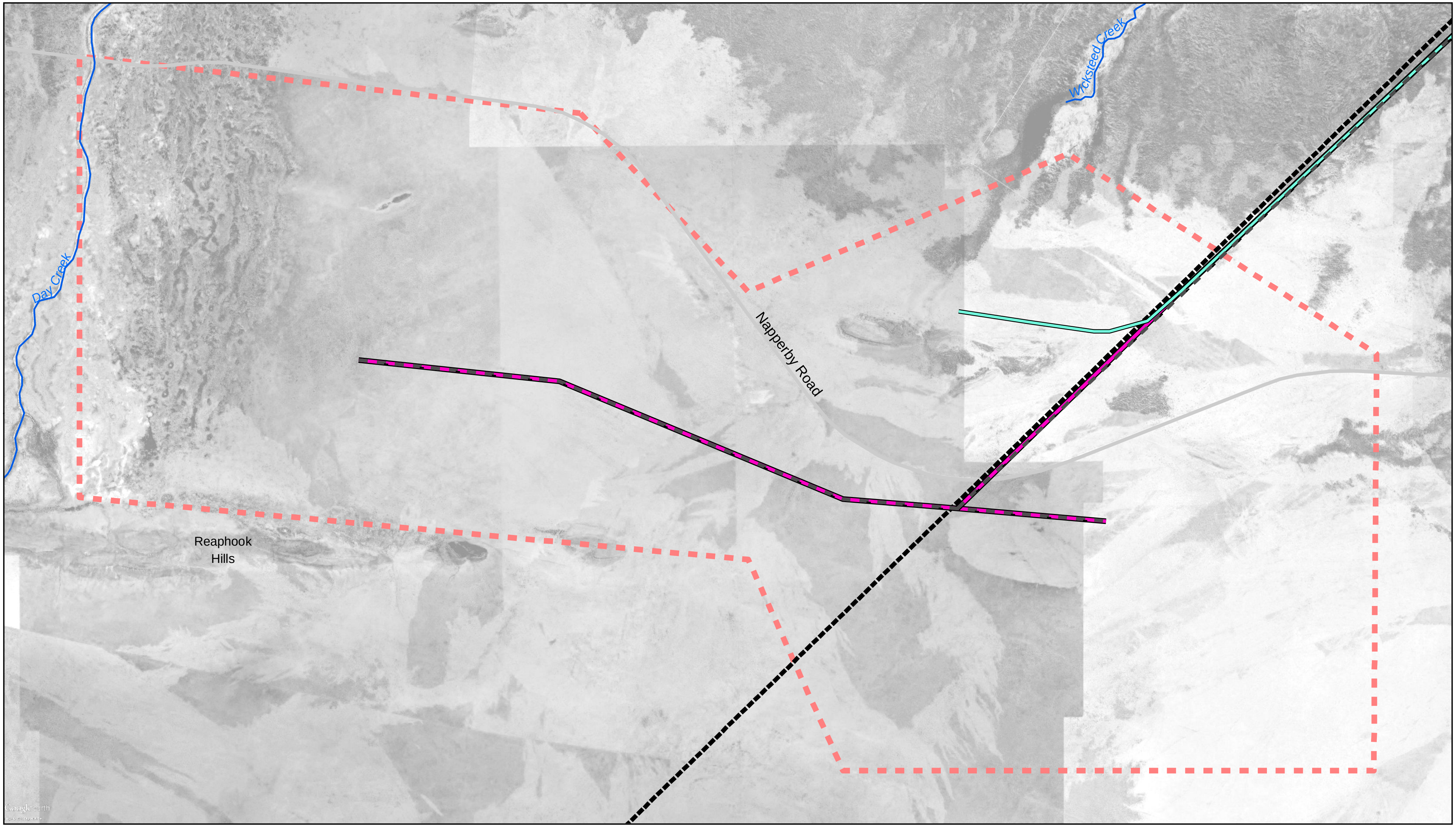
Processing site general arrangement

Figure 3-2

G:\43\22301\GIS\Maps\4322301_012_ProjectInfrastructureProcessingSite.mxd

Level 5 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: Google Earth Pro - Imagery (Date extracted: 29/04/2015). ARL - Proposed Pipelines, Proposed Mine Site, Proposed Diversion Channel Options, Tailings Storage Facility (2015). Created by: CM



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0 1 2 3 4

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Powerline
- Potable Water Pipeline
- Water Supply Pipeline
- Existing Gas Pipeline
- Waterways
- Roads
- Borefield Area Boundary

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Job Number	4322301
Revision	0
Date	13 Apr 2016

Borefield general arrangement

Figure 3-3

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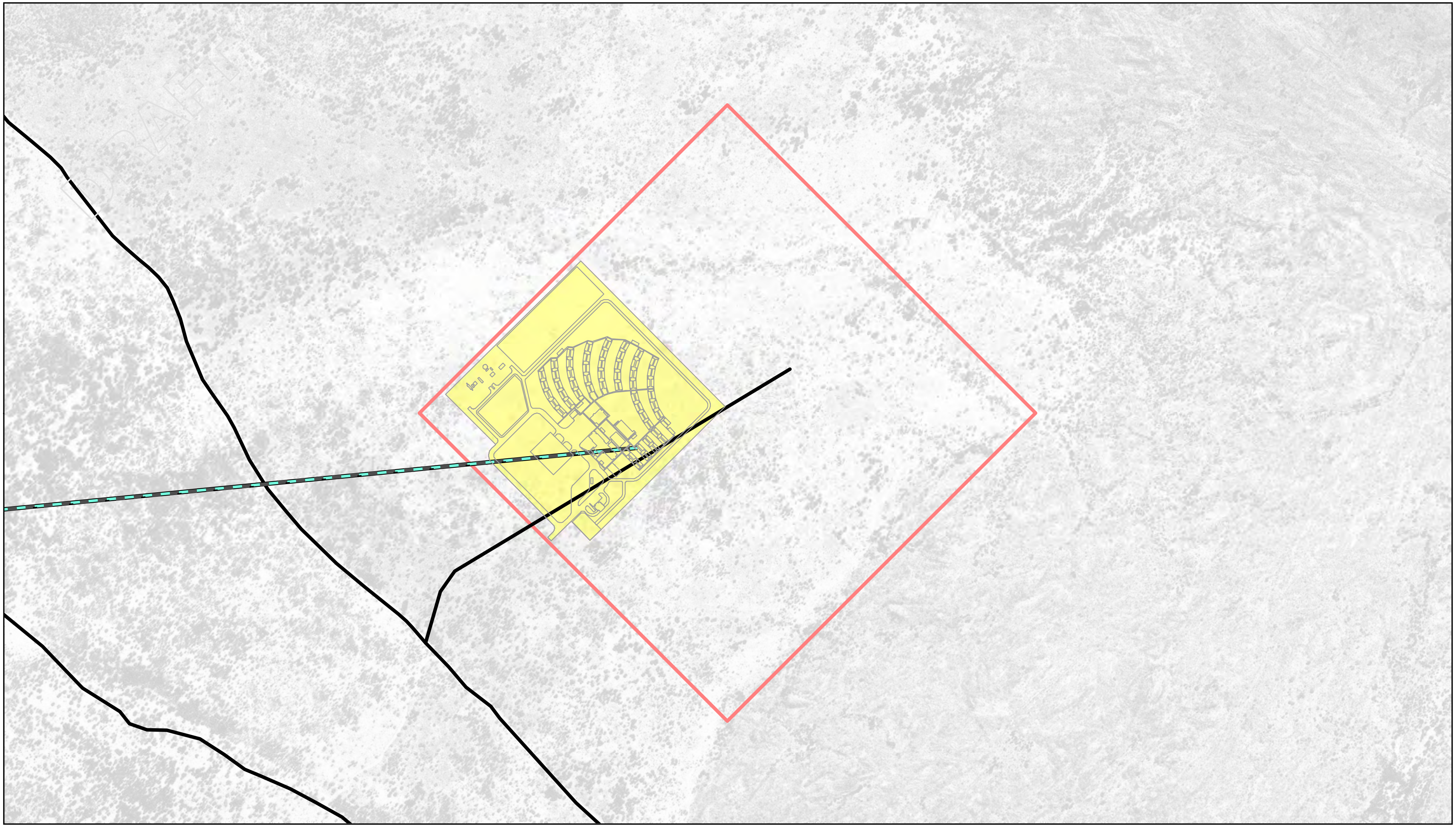
Level 5 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: Google Earth Pro - Imagery (Date extracted: 29/04/2015). ARL - Proposed Pipelines, Proposed Powerlines, Borefield Area (2015). Created by: CM



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0 100 200 300 400

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Powerline
- Potable Water Pipeline
- Access Road
- Accommodation Village Boundary
- Accommodation Village

Arafura Resources Limited
Nolans Project
Environmental Impact Statement

Job Number	4322301
Revision	0
Date	18 Mar 2016

Accommodation village general arrangement

Figure 3-4

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Level 5 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com

Data source: Google Earth Pro - Imagery (Date extracted: 29/04/2015). ARL - Proposed Pipelines, Proposed Mine Site, Proposed Diversion Channel Options, Tailings Storage Facility (2015). Created by: CM

3.3 Buildings and facilities

All site buildings and facilities will be constructed in accordance with the relevant NT building regulations and codes applicable to the Nolans site.

The concentrator and processing plant areas will comprise a mix of site erected steel framed and clad buildings and transportable modular buildings. Where practicable, the buildings will be of a modular type construction that can be manufactured off site and transported to the site. Some of the larger buildings may be formed by multiples of these transportable modules or constructed on site as required.

3.3.1 Concentrator

The concentrator is a mid-sized facility (relative to other site infrastructure) located within the mine site (Figure 3-1) featuring conventional comminution and processing technology buildings which include:

- Plant control room - including an operations area, control stations and space for computer servers a small staff amenities area.
- Crusher control room - a small prefabricated transportable building located adjacent to the crusher with working space for crusher operator.
- Plant workshop - bays open at the front with wide aprons. An overhead crane will service the bays. There will be an air conditioned room for electrical and instrument maintenance and services.
- A warehouse – to house small to medium components and provide secure storage for spare parts and consumables in high racking designed to be accessed from a personnel access platform.
- Plant crib room, change room and first aid facility - including a serving bench and wash up facilities. The clinic and first aid facility will be a single transportable building and include treatment room, office, store room and ablution.
- Reagents storage warehouse - a steel framed building with roof cover only. The concrete floor will be bunded and graded towards sumps to prevent contamination of the surrounding environment should reagents spill accidentally.

3.3.2 Processing plant

The processing plant area (Figure 3-2) buildings will include:

- A prefabricated administration building providing individual offices for senior staff and open plan partitioned work stations.
- A prefabricated amenity / crib room attached to the administration building with ablution block.
- A prefabricated emergency services facility comprising a small office and storage area for rescue equipment. There will be an undercover area for an ambulance, fire truck /rescue vehicle and emergency response trailer.
- A prefabricated operations centre complex will be a series of buildings including a control room, training room, crib room, change room, plant ablutions and laundry.
- The shower and change facility will have capacity for the entire plant workforce to change and shower each shift. The change room will contain dirty and clean change areas, showers, toilets and lockers as well as cleaner and plant rooms. Adjacent to the change room facilities will be a small commercial laundry. To control the unintended dispersion of

radioactive material, all operations personnel from the plant and mine will be required to change potentially contaminated work clothing before leaving site. Grey water from the laundry will be pumped to the RSFs.

- A laboratory will be used for sample preparation and storage and will comprise a well-equipped prefabricated laboratory building. The drainage system will include provision for handling contaminated liquids and strong acids and bases.
- A maintenance workshop will have open access and will include service bays for mobile equipment, fixed plant, electrical equipment and welding.
- A warehouse will form an extension of the workshop building. It will provide secure storage for spare parts and consumables in high racking designed to be accessed from a personnel access platform. The warehouse will house small to medium components and larger items susceptible to weather damage and stores. A secure compound will adjoin the warehouse for containerised reagent storage. This area may also contain an undercover area for ultraviolet sensitive product. The concrete floor will be bunded and graded towards sumps to prevent contamination of the surrounding environment should reagents spill accidentally.
- A product warehouse will be sized to store bulk bags of product and will include a concrete loading area external to the building.
- Wash down area and a wheel wash facility for equipment and vehicles that have come into contact with radioactive materials.

3.4 Construction

3.4.1 Project implementation strategy

Arafura will be the operations manager and contract suitably qualified companies to carry out various construction and operational roles during the project. Arafura will obtain all necessary approvals and permits and ensure that any contracting companies are aware of, and comply with, all regulatory requirements and requirements imposed by Arafura to ensure its internal standards are adhered to. Arafura will award two primary contracts:

- An engineering, procurement and construction management (EPCM) contract to carry out all necessary design, engineering, procurement, construction and commissioning works for the processing plant and infrastructure
- A separate contract with a specialist mining consultant to finalise any outstanding details of the mine design and to manage the tendering process for the award of the mining contract.

3.4.2 Construction method

Construction will generally follow four steps, as outlined below:

- **Site preparation** including staged vegetation clearing and topsoil stripping of the project site, initial WRD footprints, haul roads and access roads, TSF/RSFs and other dams, plant site and ancillary buildings and facilities. Topsoil will be stockpiled for later re-use in rehabilitation or landscaping. Graders, front-end loaders and bulldozers will level the ground to the required gradients. Cleared vegetation will be stored for later application as mulch to the rehabilitated landforms. A construction laydown area will be located at or near the processing site, with a smaller laydown area at the mine site.

- **Building platforms and hardstand areas** will be established and site drainage constructed. Foundations of major plant items and buildings will be established using concrete mixed in a temporary on-site batching plant.
- **Services corridors** will be designed and constructed to an appropriate engineered standard.
- **Equipment installation and construction of the plant** will involve assembling and installing equipment items fabricated or manufactured off-site using a range of cranes.
- **Plant commissioning** will involve testing and commissioning equipment in preparation for operations. Pre-commissioning is generally carried out using air or water. Once pre-commissioning is complete, commissioning takes place with ore, reagents and other process materials. When the pre-determined levels of output and quality are achieved, the plant will be handed over to operations personnel for optimisation and routine operation.

3.4.3 Sources of construction materials

A preliminary geotechnical site investigation was carried out by Knight Piésold Pty Ltd (2014) to evaluate foundation conditions and identify potential material borrow sources for the Nolans site infrastructure. This survey investigated a number of locations with 30 km of the Nolans site to assess construction material. Some of the sites investigated are sites used previously for highway construction or road construction on Aileron Station. Prior to project construction further geotechnical investigation will be undertaken and construction materials investigation completed. Any required regulatory approvals to source these materials for construction purposes (i.e. associated with extractive minerals title processes) will be sought prior to construction. Wherever possible the company intends using material from the pit pre-strip as construction material.

Interpretation of site conditions is based on the sub surface lithology revealed during the investigation program which included visual assessment of the in situ materials, the results of in situ field tests, and the results of laboratory testing carried out on selected representative samples collected during the fieldwork.

The geotechnical site investigation identified borrow material for earthworks construction within 30 km of the mine site, and these are summarised in Table 3-2.

Table 3-2 Summary of borrow materials

Material Type	Description	Location
Zone A	Low permeability material, generally greater than 30% fines and a PI of 8 or more.	Two possible source areas, within the pit area and to the south east of the TSF.
Zone C	Granular material (sandy gravel) with a fines content typically of 15 % to 20 %.	This material will be won from the overburden in the pit or by selective excavation from the WRD.
Zone F	Sand with less than 5% fines.	Two possible source areas, within creeks and imported from a local quarry.
Base Course	Granular material (sandy gravel) with a fines content typically of 15% to 20%	Two possible source areas, Native Gap road quarry and imported from a local quarry.
Road Aggregate	14 mm high strength stone.	One possible source area, imported from a quarry in Alice Springs.
Concrete	Variable properties but generally 40 N/mm^2	Proposed onsite batching plant during construction.

The region is known for localised, elevated concentrations of naturally occurring radioelements uranium and thorium. The aim is to ensure that all construction materials are not acid generating, and are benign with respect to activity concentrations.

3.5 Mining

3.5.1 Mineral resources

Systematic exploration of the Nolans Bore site has been undertaken by Arafura since 2001, with most of the exploration and resource definition activity confined to an area measuring 1.5 x 1.2 kilometres within the mine site boundary.

There is limited outcrop of fluorapatite at Nolans Bore, with most of the deposit covered by a thin veneer of soil and alluvium up to around one and a half metres thick. Systematic drilling indicates the widespread presence of RE mineralisation, with steeply dipping veins up to tens of metres in thickness and hundreds of metres in length, extending below 250 metres drilled depth, across large parts of the deposit. The full extent of the deposit is yet to be outlined but deeper drilling has demonstrated that mineralisation extends down to at least 430 metres below surface in the deposit's North Zone.

A total of 628 reverse circulation and diamond core holes have been drilled into the Nolans Bore deposit (Figure 3-5). The amount and overall proportion of diamond core drilling is considered sufficiently high (31%) to provide good geological control and support the estimation of higher confidence Measured and Indicated (M&I) Mineral Resources.

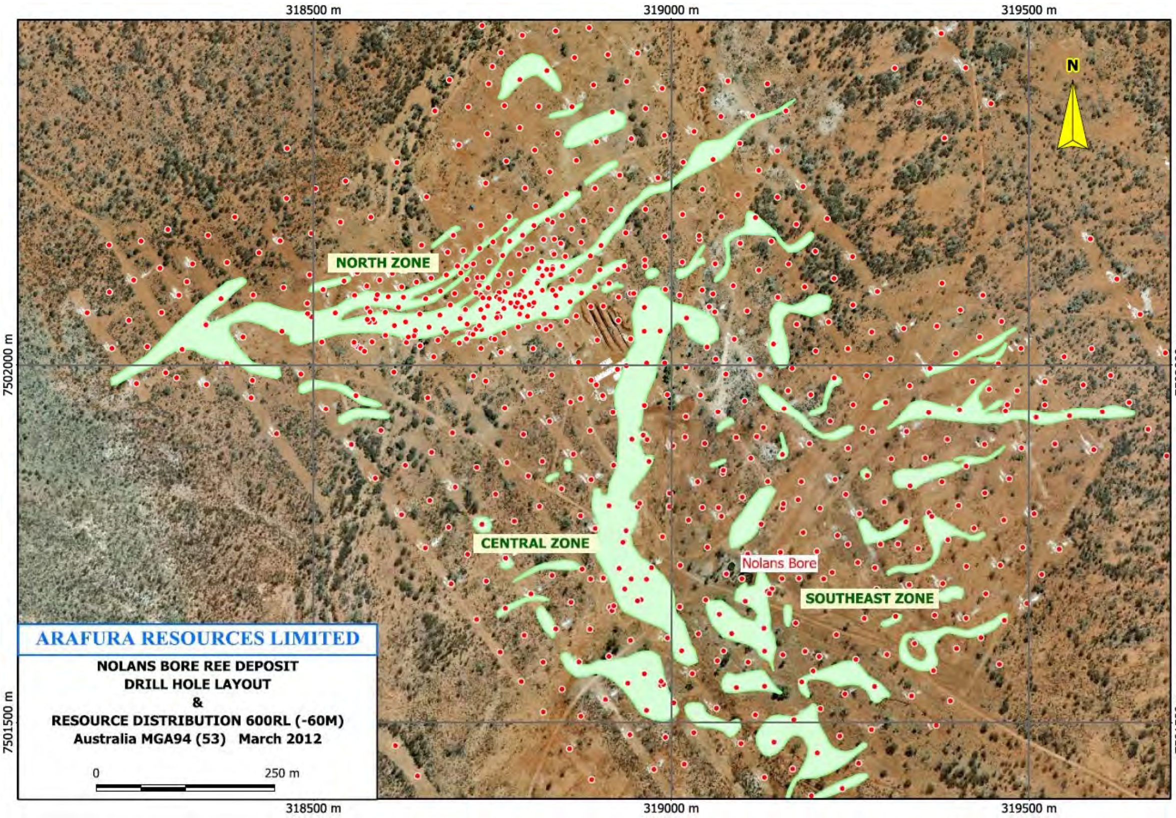


Figure 3-5 Distribution of drilling and mineral resources – plan view

An estimate of mineral resources for Nolans Bore, as at December 2014, reported above a 1% total RE oxide (TREO) cut-off grade and compliant with the 2012 JORC Code, is shown in Table 3-3, and the distribution of these resources both laterally and with depth is shown in Figure 3-6.

Resource model estimates support a 23-year production life mining the Measured and Indicated Resources only (M&I Case). Adding Inferred Resources supports a potential 43-year LOM case.

These production scenarios do have the potential to change due to an upgrade in the project's estimate of Mineral Resources reported by Arafura in October 2015, adding a further 20 per cent to the total inventory that underpins the LOM Case.

The deposit contains elevated concentrations of phosphate, uranium and thorium, averaging 11% P_2O_5, 190 ppm U_3O_8 and 2,900 ppm ThO_2 respectively, although Arafura does not initially intend to commercially recover these elements. All three elements and the radioactive decay chain daughter products of uranium and thorium will report to tailings or process residues.

Table 3-3 Mineral resources

Category	Mineral (million tonnes)	Rare Earth (TREO %)	Rare Earth (tonnes)	Phosphate (P_2O_5 %)	Uranium (U_3O_8 lb/t)
Measured	4.3	3.3	144,000	13	0.57
Indicated	21	2.6	563,000	12	0.42
Inferred	22	2.4	511,000	10	0.37
Total	47	2.6	1,217,000	11	0.41

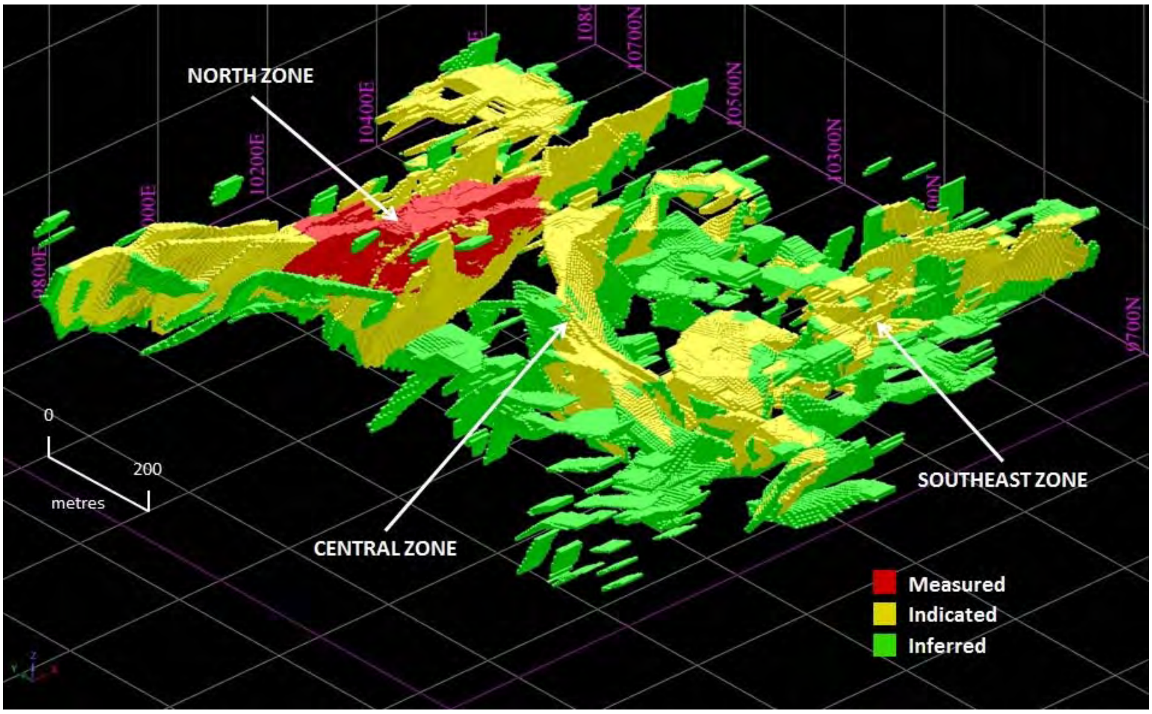


Figure 3-6 Distribution of mineral resource categories – oblique view

3.5.2 Mineralisation

The project's Mineral Resources are comprised of two broad styles of RE-bearing mineralisation:

- **Apatite mineralisation** comprises up to about 95% fluorapatite and typically contains abundant mineral inclusions of RE-bearing minerals such as monazite group minerals, allanite, thorite and numerous other RE phosphates, silicates and carbonates. The apatite itself contains variable amounts of REs but a higher proportion of REs are hosted in the mineral inclusions.
- **Calcsilicate mineralisation** tends to be lower grade than the apatite mineralisation, and is typically dominated by apatite, allanite, epidote, amphibole and pyroxene. In addition to REs, the mineralisation has elevated concentrations of calcium, phosphorous, thorium, uranium, strontium and fluorine.

The two broad styles of mineralisation described above are further subdivided into six material type categories based on geological and mineralogical characteristics, and metallurgical performance. These are listed in Table 3-4 and illustrated in Figure 3-7.

Apatite material types 1, 2 and 3 (MT123) comprise a higher grade material relative to calcsilicate material types 4, 5 and 6 (MT456). This subdivision provides the means to selectively mine and preferentially process the best performing material (MT123) early in the life of the operation, while deferring the lesser performing material types (MT456) in mine scheduling.

Table 3-4 Material types

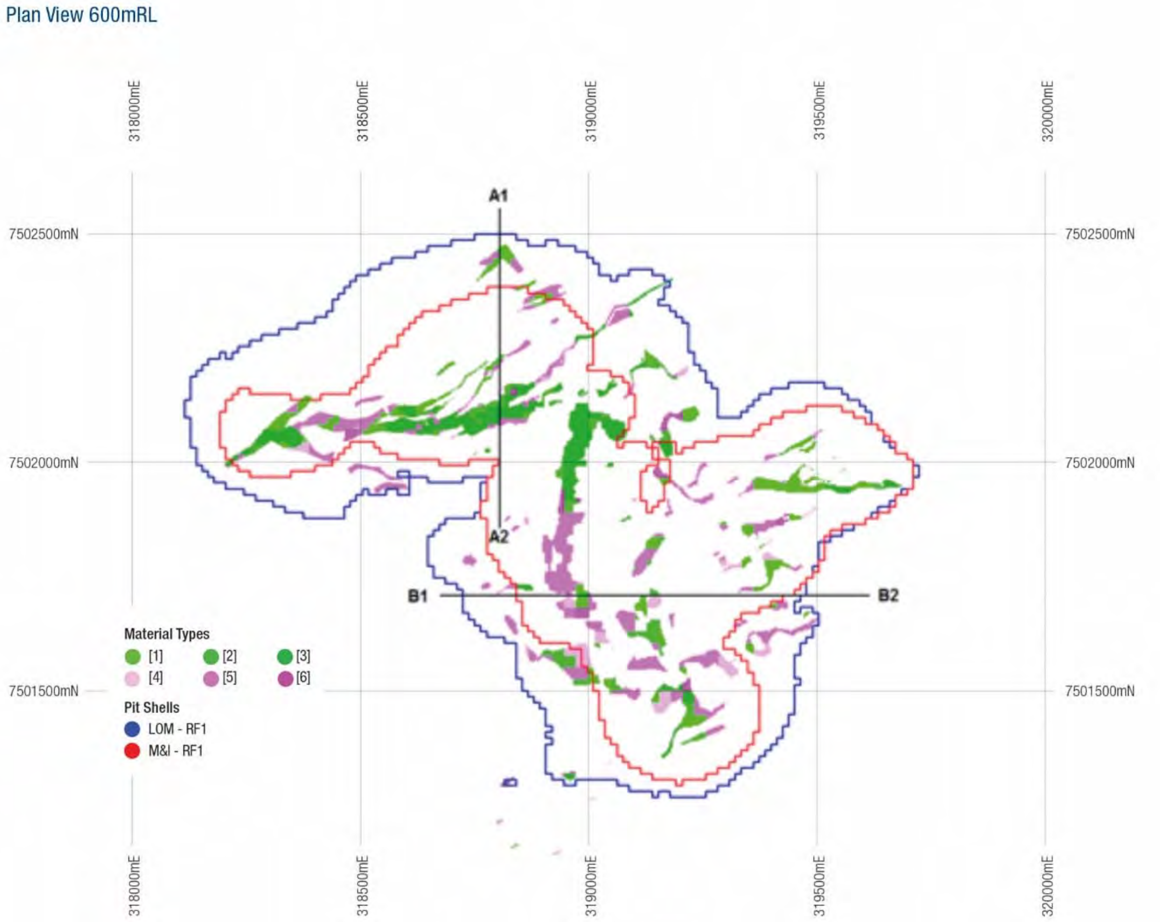
Style	Type	Description	Proportion
Apatite (MT123)	1	Cream/green apatite	17%
	2	Brown apatite	7%
	3	Brown apatite with kaolin and/or clay	21%
Calcsilicate (MT456)	4	Apatite and allanite	9%
	5	Apatite, allanite and calcsilicate	44%
	6	Apatite, allanite, calcsilicate with kaolin and/or clay	2%

3.5.3 Future exploration

Arafura has been exploring the region around the project site for REs and other mineral commodities since 1999. In that time, it has held exploration rights over approximately 6,300 km^2 of land, including the current EL that hosts the Nolans Bore deposit (EL 28473), either in its own right on in joint venture with other companies.

Arafura’s exploration methodology involves flying airborne geophysical surveys to provide a focus for detailed on-ground geological, geochemical or biogeochemical investigation (as appropriate) in advance of drilling. Often, a target area fails to deliver encouraging results at an early stage of its assessment, leading to relatively rapid turnover of ELs.

There are currently no areas, apart from the Nolans Bore deposit itself and the carbonate deposit in the north-western part of Arafura’s exploration footprint (see Section 1.4.7), where potentially mineable resources have been identified. Nonetheless, Arafura maintains a modest exploration presence in the region, and is currently acquiring exploration tenure targeting alternative models for RE deposits that have the potential to delivery complementary feed to the Nolans processing plant.


Plan View 600mRL
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318500mE
319000mE
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320000mE
7502500mN
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A1
A2
B1
B2
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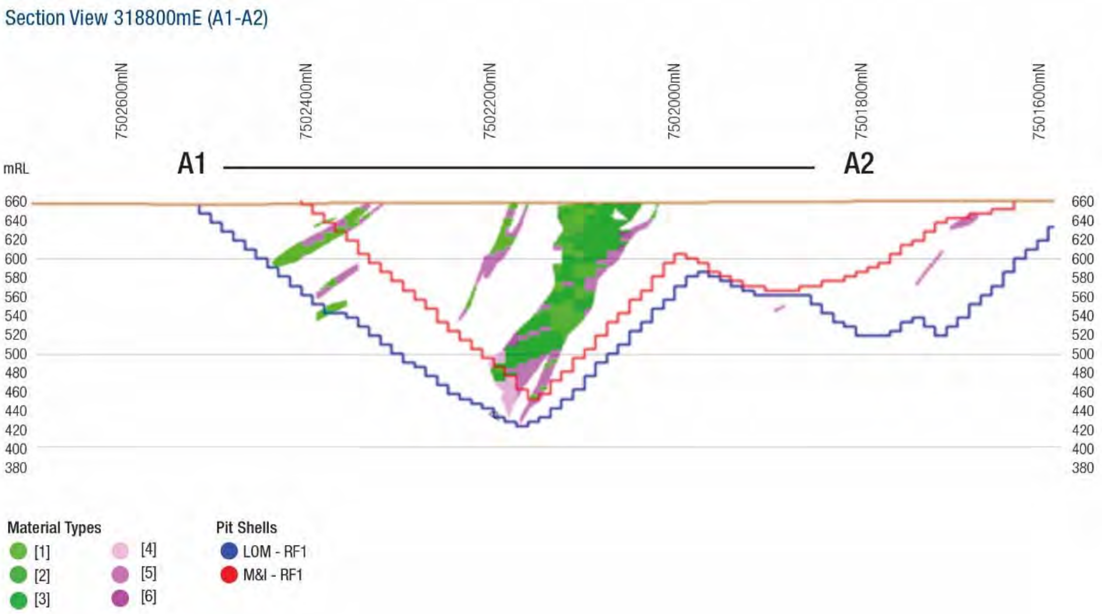
Pit Shells
LOM - RF1
M&I - RF1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7502600mN
7502400mN
7502200mN
7502000mN
7501800mN
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Pit Shells
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M&I - RF1

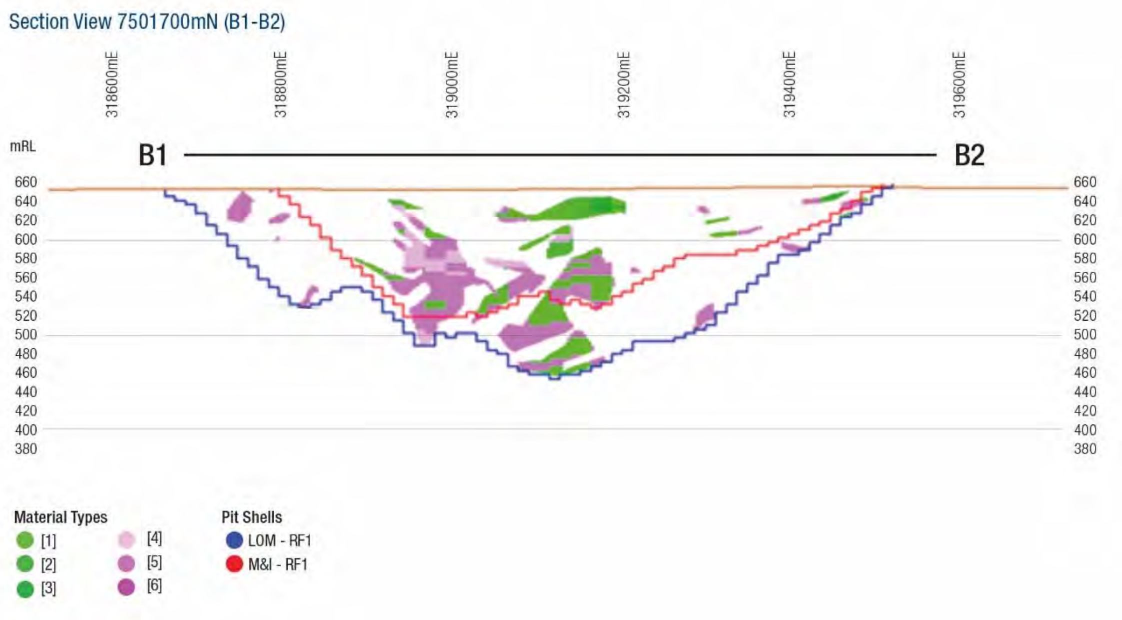

Figure 3-7 Distribution of material types

3.5.4 Mine scheduling and pit development sequence

The overall aim of the mine schedule is to ensure that sufficient ore is mined at a grade to produce an annual target of 20,000 tonnes of TREO equivalent. This will be achieved using selective mining methods from the pit, and the use of stockpiles, to optimise the required ore feed to the concentrator.

The open pit mining operation will use conventional drill, blast, truck and excavator mining methods. The truck and excavator mining method was selected because:

- A high degree of ore selectivity and blending can be achieved
- Studies have shown this method to be cost effective and often the lowest cost option and
- A high degree of operational flexibility is possible, particularly for multiple pit stages and the bench geometry associated with nested pit stages at the mine site.

3.5.5 Mining methodology

Drill and blast will be required for both ore and waste with design powder factors ranging from around 0.40 kg/BCM for oxide mineralisation and waste to around 0.60 kg/BCM for fresh mineralisation and waste. Blasthole drilling will be carried out by 89mm blasthole drills. All blasting will be undertaken using emulsion explosives selected mainly for its water resistance and resultant reduced drilling cost. The bulk emulsion explosives are delivered by a sub-contractor as a down-the-hole service which is the supply of bulk explosives on the bench.

All final design batters and interim walls will be pre-split drilled and blasted with specialised packaged explosives.

The sub-contractor's explosives plant will be located south of WRD 3 and north of WRD 5 as shown in Figure 3-1. An explosives magazine will be located near the south west corner of WRD 1.

In and adjacent to zones of mineralisation, blasthole cuttings will be sampled, radiometrically and geologically logged, and analysed to determine the type of mineralisation and TREO, P_2O_5, U and Th grade as well as other indicator elements as required. Zones of mineralisation will then be identified by the geologists as plant feed, material to be stockpiled and waste. After blasting and prior to excavation, the various material types will be marked out by the geological and grade controllers. The excavator operators will then proceed to selectively mine the various material types sending each truck to the designated destination (ROM pad, stockpile or WRD).

As an additional grade control aid, two Radiation Discriminators will be installed. The discriminators use gamma detection units to determine the average radioactivity of the material within a truck's tray and therefore provide the truck operator and grade controllers guidance regarding the destination of the truck (to the ROM pad, stockpile or WRD). This equipment will help to prevent ore being sent in error to the WRD and conversely waste being sent to the ROM pad.

The extraction sequence for the LOM case is shown in Figure 3-8. The extraction sequence provides for seven pit stages. Extraction quantities are summarised in Table 3-5.

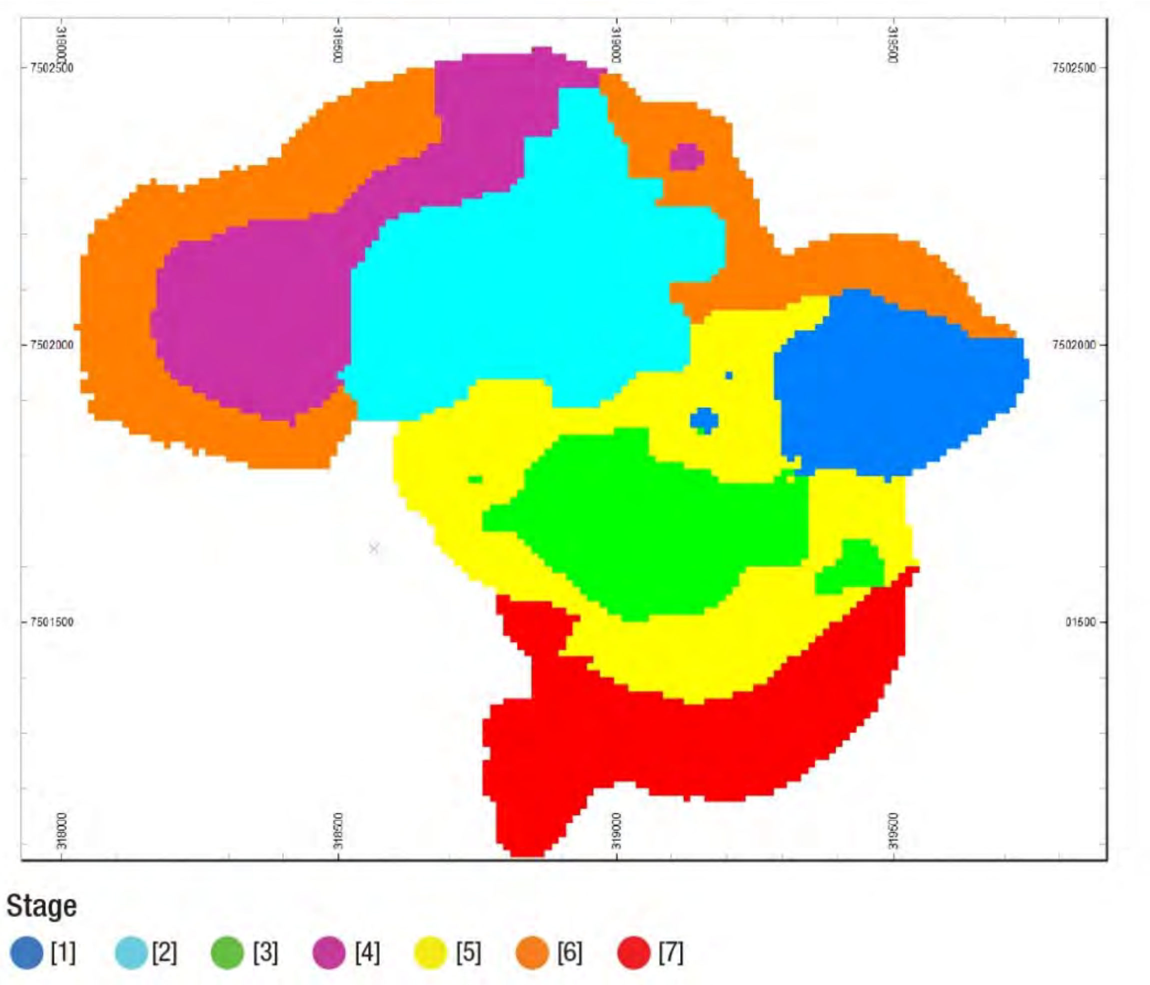

Figure 3-8 LOM pit stages

Table 3-5 LOM extraction quantities

Item	Total over LOM (tonnes)
Mined (MT123)	
Ore (ROM)	20,676,580
Ore (Long Term Stockpile)	4,791,310
Ore (Low Grade)	98,886
Mined (MT456)	
Ore (ROM)	9,763,313
Ore (Long Term Stockpile)	9,284,059
Ore (Low Grade)	9,712,754
Mined (Combined Material Types)	
Ore (ROM)	30,439,893
Ore (Long Term Stockpile)	14,075,369
Ore (Low Grade)	9,811,640
Ore - Total	54,326,902
Waste	304,092,777
Total Mined	358,419,679

The mining schedule for the LOM scenario is based on a maximum overall mining rate of 10 Mtpa ore and waste (Figure 3-9) to produce an average of 900,000 tonnes per annum of plant feed, and 358.4 Mt of ore and waste over the 43-year LOM scenario.

Mine production schedules have been generated from the pit optimisation shells based on selectively mining and processing higher grade material (MT123) in the early years of the project, and deferring the processing of lower grade material (MT456) until later years (Figure 3-9).

Plant feed (MT123 and MT456) is mined from the open pit mine and stockpiled on the ROM pad adjacent to the primary crusher. The ROM plant feed is then rehandled by a front end loader into the primary crusher. To optimise grade control, lower grade mined material is stockpiled off the ROM pad and is rehandled twice; once from the long term stockpile to the ROM, and again from the ROM to the primary crusher.

The target is to produce 20,000 tonnes of TREO equivalent per annum (Figure 3-10).

The annual material movement in tonnes for each pit stage is shown in Figure 3-11.

In any one year, a number of pit stages may be mined simultaneously. That is, when a pit stage has been developed sufficiently to expose the ore in that stage, waste development of the next stage or stages commences. Generally, one excavator fleet will remain mining ore and associated waste while the other excavator fleet(s) commences mining waste in the subsequent stage(s). For example, in Year 13, one excavator and associated trucks is mining ore in Stage 3 while the other excavators are mining waste in the upper levels of Stages 4 and 5.

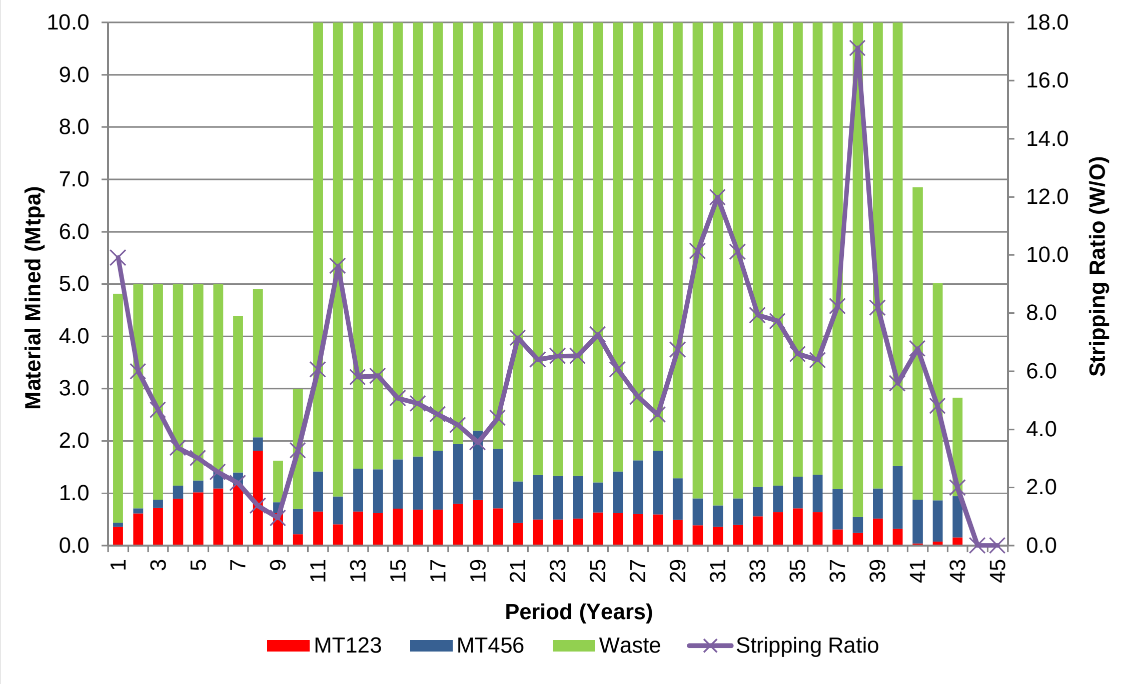

Figure 3-9 LOM production profile – material mined

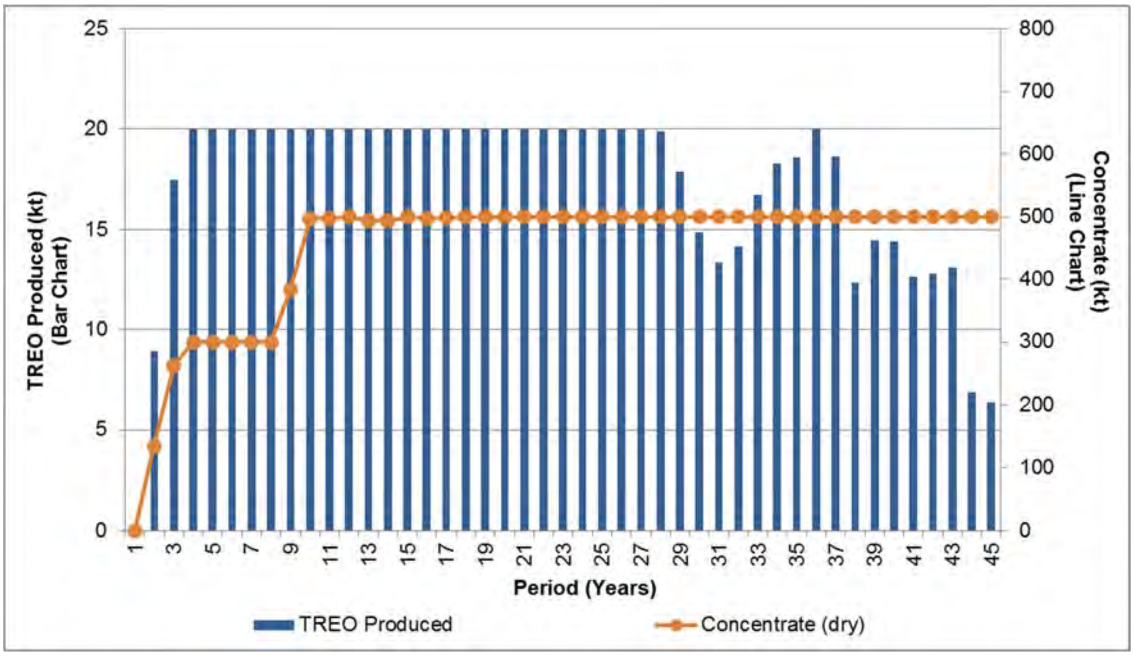

Figure 3-10 LOM production profile – concentrate and REO output

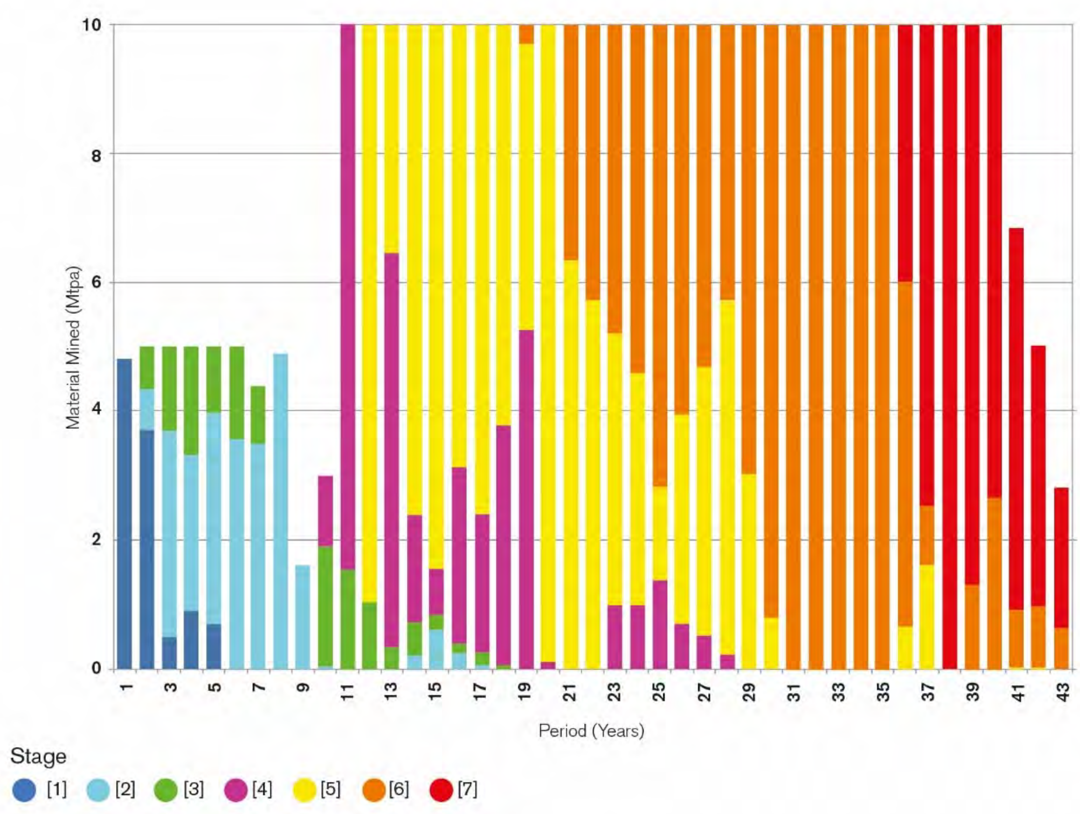

Figure 3-11 LOM production profile – pit stages

3.5.6 Mining fleet

Mining consists of some/limited blasting of waste rock and ore and use of dozers (49t CAT D9T), graders (CAT 16M) and excavators (108t Hitachi EXI 200). The ore and waste rock are loaded in the pit by excavators, into haul trucks (90t CAT 777F). The haul trucks are used to transport material out of pit to either:

- The concentrator ROM pad or Long Term Stockpile (LTS) or
- One of six WRDs (variable locations).

The primary and auxiliary mining fleets are shown in Table 3-6 below. Truck allocation to each of the excavators is dynamic, will depend on the ore and grade requirements, and ore exposures at any point in time i.e. as the ore haulage is from deeper parts of the pit and on a longer haul lead to the ROM pad, the ore excavator will require more trucks than the waste excavator(s).

On average, when the excavator fleet is at its peak, truck allocation will be four trucks allocated to the ore excavator and three trucks each to the waste excavators with a single truck under maintenance or being serviced.

Table 3-6 Mining Equipment

Type	Make and Model	Class	Activity	Peak Number
Excavators	Hitachi EXI 200	108 tonne	Load-and-Haul	3
Trucks	Caterpillar 777F	90 tonne	Load-and-Haul	11
Dozers	Caterpillar D9T	49 tonne	Auxiliary	3
Graders	Caterpillar 16M	16' blade	Auxiliary	2
Service Truck	Man 6 x 6	-	Auxiliary	1
Water Trucks	Man 6 x 6	-	Auxiliary	2
Rock breaker	Caterpillar 336DL	-	Auxiliary	1
Lighting Plant	Allight	-	Auxiliary	12
Front End Loaders	Caterpillar 990H	-	Auxiliary	2
Light vehicles	Various	-	Auxiliary	22
Surface Crawler Drill	Sandvik DP1100	89 mm dia. hole	Blast Drilling	6
RC Drill	Atlas Copco RC 127	127 mm dia. hole	Grade Control	1
Dewatering Pump	Chesterton	-	Dewatering	3

3.6 Processing

3.6.1 Overview

The Nolans process configuration falls into three geographical and processing categories (Figure 3-12):

- Comminution and beneficiation
- Rare earth extraction
- Rare earth separation.

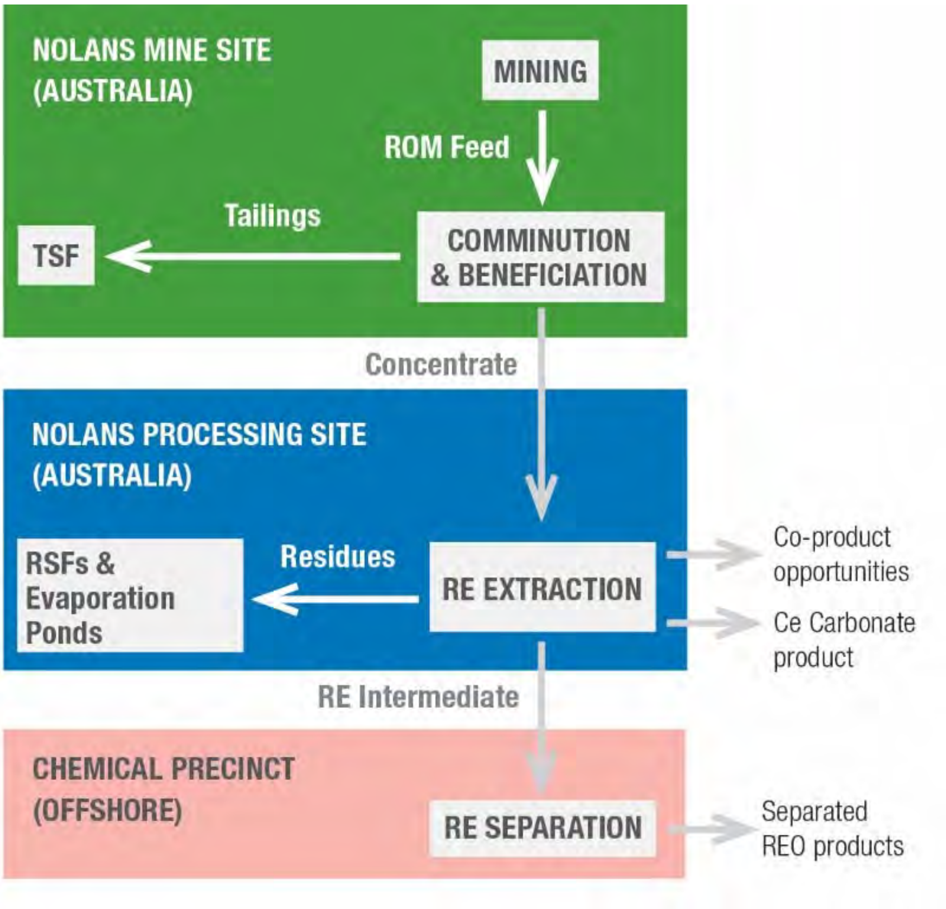

Figure 3-12 Process configuration

3.6.2 Mine site processing

Mining operations will deliver broken ore to a ROM pad (from which a front end loader will feed the crushing circuit) as well as to the LTS. Plant feed (MT123 and MT456) is mined from the open pit mine and stockpiled on the ROM pad adjacent to the primary crusher. The ROM plant feed is rehandled once and is processed soon after being mined.

Lower grade material mined during the early years of the Project is stockpiled off the ROM pad and is rehandled twice; once from the Long Term Stockpile to the ROM, and again from the ROM to primary crusher.

Waste rock will be hauled from the pit to the nearest WRD.

The concentrator comprises comminution and beneficiation circuits (Figure 3-13). Comminution includes a crushing circuit fed by front end loader, and ore is then conveyed to a single ball mill for grinding.

In the beneficiation circuit, ground material is passed through a wet high intensity magnetic separation (WHIMS) circuit to isolate RE-bearing magnetic minerals into a concentrate. This concentrate is then reground and upgraded using flotation cells to produce a RE-rich concentrate.

The reject from this magnetic process (i.e. the magnetic tails) are further processed through a flotation circuit to produce a phosphate-rich concentrate. The RE and phosphate concentrates are then combined as the feed material and pumped in a slurry to the processing plant at the processing site. All rejected magnetic and flotation tailings are then combined and pumped to a flotation TSF at the mine site.

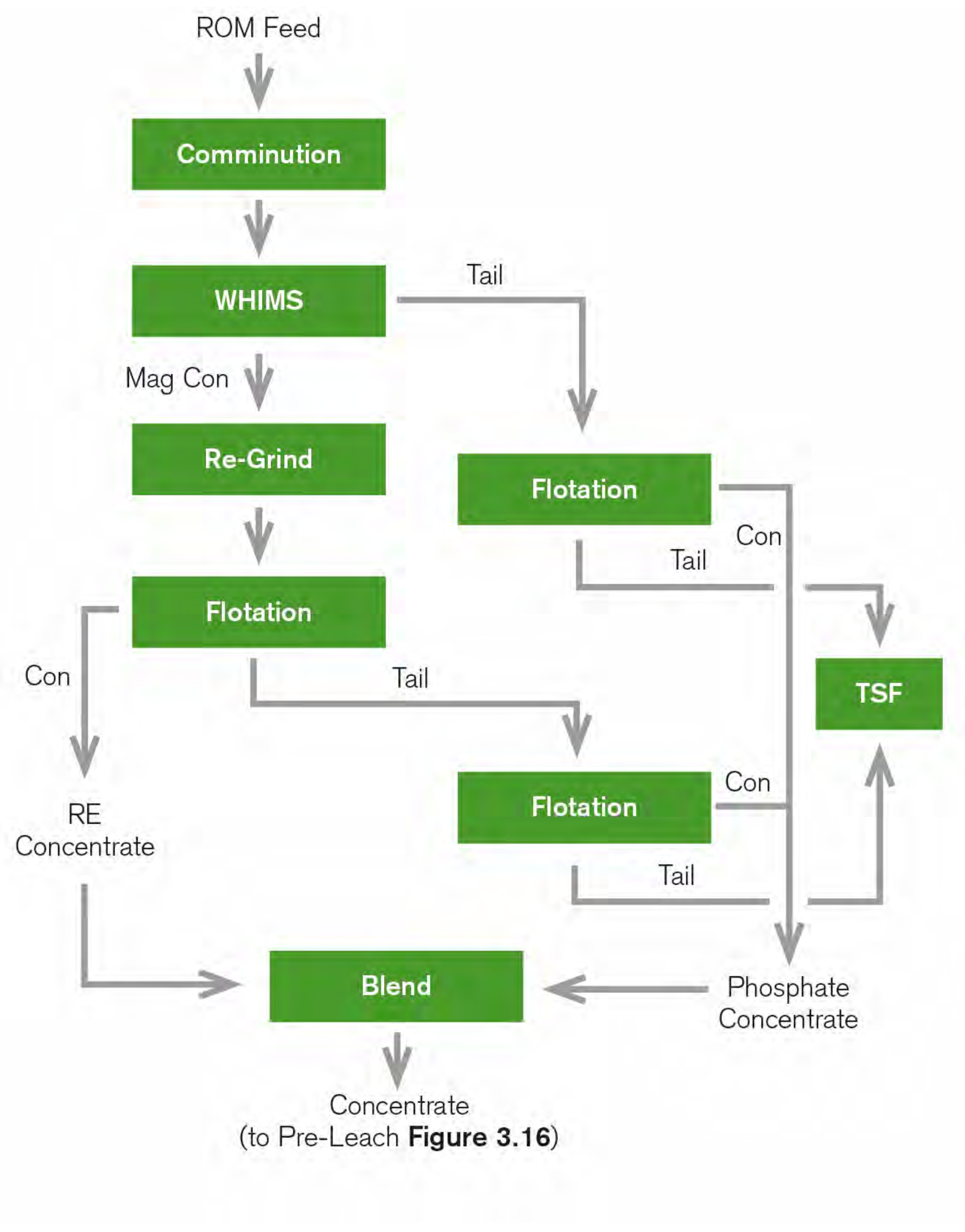

Figure 3-13 Concentrator circuit (Source: Arafura 2014)

3.7 Processing site

The processing site is located eight kilometres south of the mine site and hosts RE extraction processing units, a sulfuric acid plant, RSFs, evaporation ponds and other infrastructure to support the operation (Figure 3-2).

Concentrate will be pumped through a HDPE slurry pipeline from the concentrator to the processing site. The slurry pipeline will run above ground within a compacted earth bunded corridor, with event ponds located at low points along the alignment. Centrifugal pumps, arranged in series will be utilised to pump the concentrate slurry along the pipeline. The pump arrangement has been specified for a head of 198 m, the primarily component of which is friction losses within the pipe.

The processing plant comprises the following major processing facilities (Figure 3-14):

- Sulfuric acid pre-leach (SAPL)
- Sulfation and water leach
- Double sulfate precipitation (DSP) and purification and
- RE chloride intermediate and cerium (Ce) carbonate production.

The processing plant has several ancillary plants associated with it, such as a sulfuric acid plant, steam and gas power generation and water treatment as well as other infrastructure and services.

3.7.1 Sulfuric acid pre-leach

Mineral concentrate is received from the concentrator as a slurry at the processing plant and following dewatering, is fed to the SAPL process stage. The SAPL process produces a solid feed, containing the majority of the REs, for the sulfation process. It also produces a pre-leach liquor containing the remaining REs, for use in the water leach process. The solid feed material from SAPL is dewatered prior to being transferred to the sulfation process.

Solid sulfur will be sourced internationally and containerised at Darwin Port before being transported to site. It is anticipated that around 20,000 tonnes of solid sulfur will be transported to site quarterly for stockpiling and subsequent use (see also Section 3.10.4). It will remain in shipping containers whilst on site, prior to use.

3.7.2 Sulfation (acid bake)

A relatively low temperature acid bake process using concentrated sulfuric acid is used to sulfate the solid feed material, and liberates the REs for subsequent processing and extraction. This lower temperature process minimises the energy requirement for the sulfation process and offers a broader range of processing technologies.

3.7.3 Water leach

The sulfated material is leached with a mixture of pre-leach liquor, filtration wash filtrates and water. The water leach liquor is processed to recover REs and the solid residues are neutralised in the acid neutralisation section prior to final on-site disposal in the water leach RSF.

3.7.4 Double sulfate precipitation

Water leach liquor produced in the water leach section passes to the double sulfate precipitation stage. The addition of sodium sulfate in the double sulfate precipitation stage selectively precipitates the REs as a double sulfate salt. This is subsequently filtered and washed for further processing.

Liquor streams containing elevated levels of sodium sulfate are collected and evaporated for re-use in the double sulfate precipitation stage. Evaporation ponds are used to evaporate excess process fluids.

The RE-depleted double sulfate precipitation filtrate is neutralised with carbonate and lime in a two stage impurity removal process to produce a residue containing thorium and a phosphate residue that contains most of the uranium present in the Nolans ore. These residues will be stored and managed on-site in dedicated RSFs.

3.7.5 Conversion to hydroxide

The double sulfate precipitation solid salt is mixed with sodium hydroxide to convert it to a RE hydroxide solid. This solid is washed and dried prior to further processing. During the drying operation, in the presence of air, most of the cerium which is present as Ce^{3+} is oxidised to Ce^{4+}. This assists subsequent separation from the other REs to produce a cerium carbonate product during intermediate-stage processing.

3.7.6 Hydroxide dissolution

The dried RE hydroxide undergoes a selective re-leach with dilute hydrochloric acid to produce a mixed RE chloride liquor containing low levels of cerium. As the cerium is predominantly in the oxidised Ce^{4+} state it remains relatively insoluble in the solid phase during this selective re-leach process.

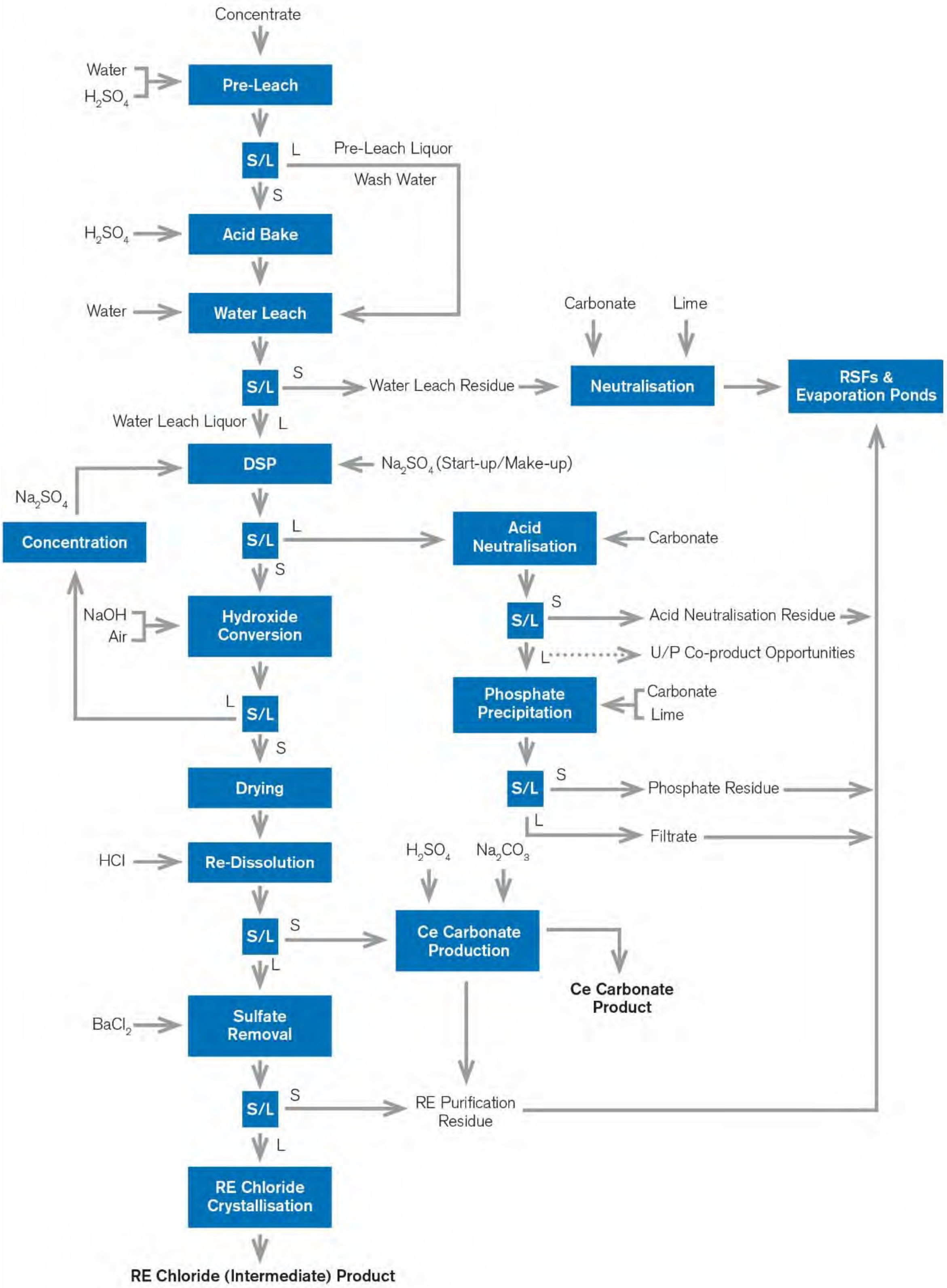

Figure 3-14 RE extraction circuit (Source: Arafura 2014)

3.7.7 Intermediate processing products

The RE chloride liquor from hydroxide dissolution is treated with barium chloride to remove residual excess sulfates and subsequently crystallised as an RE intermediate feed for transport and further processing at an offshore separation plant.

The cerium-rich solid from the hydroxide dissolution is treated to remove the residual thorium as a chemically stable precipitate and this precipitate is sent to the on-site neutralisation RSF. The cerium-rich liquor is precipitated by the addition of sodium carbonate to produce a cerium carbonate product.

The RE chloride intermediate and cerium carbonate products will leave the facility in bulk bags stored within standard shipping containers for transport to Alice Springs by road and then to Darwin via rail to the port for export. The former product will be shipped to the separation plant for refining. The latter product is targeted for direct sale to international customers.

3.7.8 Chemical precinct

Rare earths will be separated into final refined products at an offshore separation plant.

The separation plant will be subject to a separate approvals process and is excluded from the scope of this EIS.

3.8 Power demand

The power demand for the Nolans site has been estimated from detailed load lists for the mine and concentrator, processing plant and infrastructure assets including the accommodation village and water supply (Table 3-7).

Table 3-7 Power demand summary

Area	Power Demand (kW)
Mine and concentrator	9,000
Processing plant	8,000
Accommodation village, bores, water transfer, potable water, sewerage	1,500
Total	**18,500**

3.8.1 Power supply

There is no local grid supply opportunity in the region. Power demand will be serviced by cogeneration from a sulfuric acid plant and gas fired on-site generation located at the processing site.

The sulfuric acid plant associated with the processing plant will generate power via a steam turbine from the steam arising from burning sulfur. This is a common feature of sulfuric acid plant design.

Acid plant vendor supplied information indicates that the sulfuric acid plant should deliver a net power output of approximately 6 MW over and above its internal consumption requirements.

The project will require additional power over and above that available from the sulfuric acid plant and it is planned that this will be generated by a gas turbine facility located at the processing site. The facility will also maintain site-operating capability during acid plant or steam turbine/generator outages, i.e. maximum power output of 18.5 MW.

The load and generating capacity from the waste heat of the sulfuric acid plant leaves a normal operating natural gas fired generation requirement of approximately 12.5 MW. This is expected to provide the optimum steam/power demand flexibility for the site.

The Amadeus Basin to Darwin high pressure gas pipeline is adjacent to the Nolans site. Arafura has engaged in discussions with the pipeline operator and a number of existing and prospective gas producers regarding a long-term gas supply opportunity for the project. The close proximity of the Nolans site to the gas pipeline eliminates the need for a significant offtake connection pipeline. The supply capacity and capability easily exceed the project's process gas demands.

In addition, emergency diesel generators will be located at three of the principal Nolans site areas (mine site, processing plant and the accommodation village) to maintain safe emergency power requirements for personnel, and safety critical drives and personnel safety in the event of a major power outage. Processing plant emergency generators will also provide black start capability.

While the processing plant is under construction, power will be generated at the accommodation village using diesel or gas generator sets which will also provide it with longer term emergency power.

3.8.2 Power distribution

The power plant will be located at the processing site adjacent to the sulfuric acid plant. The site layout requires overhead power lines to distribute power to infrastructure at the processing site, the mine site (approximately eight kilometres north of the proposed generation facility), the raw water collection pond and borefield area (approximately 13 km south west of the proposed generation facility), and the accommodation village (approximately five kilometres south east of the proposed generation facility).

High voltage (HV) overhead lines from the processing plant will transmit the power to the site users via kiosk substations. In total, there will be approximately 30 km of overhead lines.

The borefield service corridor (Figure 3-3) to the raw water collection pond will include a high voltage overhead power line. The pipeline bore field pump stations will be fed from a pole-mounted transformer, while the pumps in the borefield pump stations will be powered by diesel generators. If a decision to distribute power to individual bores within the borefield is made, the length of power lines required will increase significantly but will result in minor additional disturbance.

Power will be transmitted to the accommodation village by overhead high voltage (11 kV) conductors. At the village there will be a kiosk substation from where power will be distributed below ground at low voltage (415 V).

3.9 Tailings and residue management

3.9.1 Configuration

The Nolans site requires tailings and residues storage facilities which include:

- A flotation TSF adjacent to the concentrator at the mine site (Figure 3-1) and
- Separate water leach, neutralisation and phosphate RSFs, and evaporation ponds adjacent to the processing plant (Figure 3-2).

The LOM storage capacity and footprint of these facilities are summarised in Table 3-8 and Table 3-9 below.

The envelopes shown in Figure 3-1 to Figure 3-4 are larger than the LOM footprint areas represented in the tables below, to allow for future expansion of these facilities and extensions to the LOM should this be required.

Table 3-8 Tailings and residues storage

Facility	Embankment height (m)	Number of cells	Total footprint (ha)	Water storage capacity (Ml)	Tailings/ residue storage (Mt)
TSF	25.1	2 or more	~100	-	~45
Phosphate residue	24.0	2	~60	-	~13
Impurity removal residue	24.1	2	~150	-	~54
Water leach residue	20.9	2	~114	-	~33

Table 3-9 Quantities of tailings and residues

Facility	Slurry throughput (wet Mtpa)	Slurry throughput (dry Mtpa)	Slurry input (percentage solids)	Salinity (specific gravity)
TSF	1.17	0.450	38.6	1.000
Phosphate removal	0.4	0.141	34.9	1.068
Impurity removal	1.48	0.592	40.0	1.025
Water leach	1.07	0.357	33.5	1.007

Table 3-10 Other ponds

Facility	Embankment height (m)	Number of cells	Total footprint (ha)	Water storage capacity (Ml)	Tailings/ residue storage (Mt)
Evaporation pond	2.5	6	60	1,500	0
Sodium sulfate pond	2.5	3	10	250	0

3.9.2 Design and operation

The TSF and RSFs will collect leachate and minimise seepage, whilst also maximising tailings and residue densities.

Knight Piésold (2014) assessed the facilities as having an ANCOLD High C consequence category classification, based on an assessment of all criteria (see Table 3-11) and a conservative estimate of “population at risk”. The resultant consequence category was a conservative assessment in the absence of a detailed “population at risk assessment” at the time of preparation of the report (2014).

Table 3-11 Severity level impact assessment

Criterion	Impact Category
Damage to infrastructure	Medium
Business importance	Medium
Public health	Minor
Social dislocation	Minor
Impact area	Medium
Impact duration	Medium
Impact on natural environment	Minor

In 2016, ATC Williams undertook a Flotation TSF Failure Impact Assessment (Appendix J), including a detailed population at risk assessment (excluding site personnel). The ANCOLD consequence category classification was assessed as low, thus the average recurrence interval (ARI) and possible maximum flood (PMF) indicative storage facilities designs (i.e. freeboard storage for 1 in 100,000 ARI or PMF 72-hour event are conservative.

The TSF will have a low permeability soil liner and the embankments will be constructed from suitable mine waste material. This waste will be non-mineralised country rock. Decant water will be recycled to the processing plant. Any additional construction materials will be sourced locally from areas identified previously. These volumes will be subject to additional regulatory approval for extractive purposes. A more detailed geotechnical evaluation will be completed prior to construction.

The current RSF design incorporates a HDPE/low permeability soil liner system, combined with basin drainage and a leakage collection and recovery system.

The purpose of the drainage system is to reduce the water head on the underlying liner and thus reduce seepage rates. The water from the drainage system will be collected and discharged into the pond within the same facility. Ponded water will evaporate and water will not be recycled to the processing plant due to the quality of the water and its detrimental impact on the operation of the plant.

Detailed chemical characterisation of these process residues is in progress. Following receipt of this work an alternate design for the RSFs may be contemplated which removes the HDPE liner. The life of a HDPE liner is around twenty years and the project currently contemplates 43 years LOM. Any new design concept will place greater emphasis on recovery of entrained water or seepage rather than containment.

The evaporation and sodium sulfate ponds will be lined with an HDPE liner. Excess process liquor plus RO plant reject and treated sewage effluent will be directed to one of the evaporation ponds after which the flow will be directed to the next pond in sequence. Over time the liquor will concentrate through evaporation and the remaining brine in the cell will be pumped to the impurity removal RSF to reduce the accumulation of precipitate in the evaporation ponds. The cell will then be available to receive excess process liquor for the next cycle.

Waste storage facility design drawings are presented in Appendix E. The size and configuration of waste storage facilities may change, but typical design features will remain the same.

Tailings and residue management plans will be developed following finalisation of engineering design. Waste facility operations will also comply with procedures outlined in the radiation and water management plans within the Environmental Management Plan.

3.9.3 Monitoring and closure

During operation a monitoring program for the TSF and RSFs will be developed to monitor their performance and integrity during operation, and to assist management of these facilities post closure. This will include groundwater monitoring stations to ensure early detection of groundwater level and/or quality changes. Embankment piezometers and survey pins will be installed to monitor stability and other parameters. It is proposed that the TSF and RSFs will be progressively covered with a layer of benign stable rock during operations if practicable to limit the area of exposed residues.

Closure of the TSF and RSFs will be in accordance with the approved mine closure and rehabilitation plan. At closure the TSF and RSFs will have a layer of around two metres of benign waste rock placed over them to limit natural erosion and ensure long term security of the contained tailings and residues. Following closure of the facilities a modified monitoring program will be developed and agreed with regulators to monitor and manage the performance of these storage structures.

3.10 Wastes and hazardous material

3.10.1 Waste rock dumps

Six waste rock dumps (WRDs) will receive a LOM waste quantity of around 158 million loose cubic metres constructed to a height of about 50 m above the land surface built in ten metre lifts interspersed with five metre wide berms. WRD capacities are shown in Table 3-12 and the locations are shown in Figure 3-1. The design criteria are summarised in Table 3-13

Waste rock will be hauled to the nearest waste rock dump from the pit stage being mined in the pit at that time. For example, in Year 13 waste from Stage 3 is sent to Dump 2, waste from Stage 4 to Dump 1, and waste from Stage 5 to Dump 2, 3 or 4, depending which is nearer to that part of Stage 5 being mined.

A swell factor of 30% has been applied to designs, but with traffic compaction and consolidation over time, this may actually be closer to 25% in operations. Therefore, a swell factor of 30% is expected to be an upper limit and to provide a safety margin in WRD design capacities.

A total storage area of 95 ha has also been set aside for topsoil storage (Figure 3-1). Top soil storage will progressively be increased as WRD footprints increase during mining. To ensure that topsoil remains viable, storage will be kept to a minimum and top soil will also be used progressively as WRDs are rehabilitated and closed.

Table 3-12 Waste Rock Dumps

Waste Rock Dump Number	Volume (Mlcm)	Footprint (ha)
1	77.14	212.61
2	26.87	101.64
3	14.30	68.22
4	22.60	99.19
5	14.57	70.36
6	4.11	38.04
Total	**159.59**	590.06

Table 3-13 WRD design criteria

WRD design parameter	Quantity	Unit
Lift	10	m
Overall face angle	16	Degrees
Berm width	5	m
Road gradient	10	%
Road width	35	m
Stand off from pit crest	50	m
Maximum dump height (to maximum RL)	50 (~730)	M (mRL)
Stand off from infrastructure	35-50	m
Swell factor	30	%

3.10.1 Naturally occurring radioactivity

The area of the Nolans Bore deposit, including both the surface layers and the mineralised layers, contains elevated concentrations of naturally occurring uranium and thorium. Higher uranium and thorium concentrations are naturally associated with the RE mineralisation.

Arafura has conducted radiological monitoring since commencement of systematic exploration work in the mid-2000s. This has enabled Arafura to characterise the natural background radiation levels, including elevated levels of uranium and thorium associated with the project and to develop appropriate management practices (details of the existing background levels are provided in Chapter 12 of this EIS).

The project does not intend to extract and commercially recover the uranium and thorium, and consequently any uranium, thorium or radioactive decay products (known as radionuclides) in the ore are considered impurities, requiring removal. The rejected radionuclides will be part of the waste streams that report to the TSF and RSFs.

During operations, some waste rock will be mined that has a radionuclide concentration exceeding 1 Bq/g. This concentration is recognised as the level at which a material is defined as radioactive and therefore subject to control (ARPANSA 2015). The waste rock that exceeds 1 Bq/g will be encapsulated during operations and progressively covered with inert waste rock material. This rock coming from the mining operation will be quickly classified into its respective category (radioactive or benign) by the truck passing under a sensor. The sensor will direct the driver to the appropriate dumping location within the mine site area.

The radionuclide concentrations through the operation's processing circuits and in the tailings have been determined through test work undertaken by ANSTO (Australian Nuclear Science and Technology Organisation) in Sydney, and this is described in Chapter 12 and Appendix P of this EIS. JRHC Enterprises and Radiation Advice & Solutions, who are regarded as technical specialists in the radiation field, have completed additional calculations and estimations.

At closure, the TSF and RSFs will be covered with sufficient inert waste rock material to ensure that the underlying tailings material is secured from erosion and that radiation levels are less than 1 Bq/g at surface.

As part of the environmental impact assessment, the radiological impact of the operations on workers, the public and the environment has been assessed and is addressed in Chapter 12.

3.10.2 Potential acid forming material

Acid forming material risk assessment and management is addressed in Chapter 8 and Appendix L. Acid and metalliferous drainage (AMD) assessment has revealed low sulfur content and significant apparent neutralising capacity in most lithologies and waste streams. The static and kinetic AMD and geochemical testing indicates that the proposed waste rock, ore and pit wall material has a low risk of generating acidic, metalliferous or saline leachate.

Conceptually, potential acid forming (PAF) material will be contained and encapsulated within benign waste in designated areas of the contaminated WRD. Based on the waste rock characterisation assessment completed for the project there is a low risk of acid metalliferous drainage resulting from the waste rock associated with the project.

Additional information relating to the characterisation of the expected waste rock properties is contained in Chapter 8.

3.10.3 Process waste streams

The following waste streams will be generated by the project with each waste stream reporting to an individual storage facility (see Section 3.9):

- Flotation tailings from the concentrator
- Phosphate residue from the processing plant
- Impurity removal residue from the processing plant and
- Water leach residue from the processing plant

Sodium sulfate is not considered a waste stream as it will be recovered for re use in the processing plant.

Expected slurry volumes are summarised in Table 3-9 and the location of the TSF and RSFs is shown in Figure 3-1 and Figure 3-2.

The project's process flowsheet has phosphate, uranium and thorium reporting to waste streams.

Hazardous process materials

Detailed logistics modelling indicates that the project will have annual movements of approximately 190,000 tonnes of in-bound raw materials to the Nolans site, and these will predominantly be in the form of standard intermodal cargo. Arafura has engaged with the major operators and service providers to assess and ensure access to the required infrastructure and to incorporate the most efficient solutions for cargo movements. The transport impact assessment is described in Chapter 17 and Appendix V.

Sulfur and sulfuric acid

Sulfuric acid will be required both for the start-up of the acid plant and during the initial stages of ramp-up until consumption rates justify the commencement of on-site acid production. Arafura is working with the owners and the operators of the bulk tank facility at the Port of Darwin to facilitate handling of internationally sourced concentrated sulfuric acid via existing infrastructure. Where transport volumes justify the investment, the company will work with the owners and operators of existing bulk handling installations to facilitate investment in additional capacity.

Caustic soda and hydrochloric acid

It is expected that hydrochloric acid will be sourced from a regionally based supplier and delivered in ISO tank containers. Alternatively, internationally sourced hydrochloric acid will be delivered in bulk to Darwin for subsequent transfer to ISO tank containers.

Caustic soda will be procured on the international market and delivered in bulk to Darwin for subsequent transfer to ISO tank containers.

This dedicated fleet of ISO tank containers will be transported on standard rail and road intermodal services between Darwin and Alice Springs and the Nolans site (see Section 3.12).

3.10.4 Other raw materials and reagents

All other inbound raw materials and reagents such as soda ash will be containerised and transported using intermodal services. This maximises the use of standard services while maintaining flexibility and minimising cost. Sourcing of other critical raw materials will include a matrix of local, regional, national and international suppliers in order to manage the supply related risk. Diesel for the Nolans operation will be delivered by road tankers directly from Alice Springs (refer Chapter 17 and Appendix V.)

Additionally, Arafura has identified several potential carbonate (marble and calcrete) sources at surface within 30 km of the mine site on land over which it maintains exploration rights. Any approvals regarding development of a small quarrying operation to produce carbonate product, and the road transport of this product on Pine Hill and Aileron stations between the quarrying operation and the processing site, will be subject to a separate process.

3.10.5 Rare earth products

Out-bound RE product from the Nolans site will utilise existing road and rail capacity in addition to the Port of Darwin infrastructure. The products from the processing plant will be packed in bulk bags and transported in standard shipping containers via Darwin and international shipping routes. The RE intermediate product will be shipped via standard existing container freight routes to an offshore separation plant. The cerium carbonate product will be shipped to customers by similar means.

3.10.6 Wastewater and water treatment

Wastewater from the accommodation village and non-process wastewater from the processing site and the mine site will either be pumped to a common sewerage treatment plant located adjacent to the processing plant or to a second small treatment facility installed at the mine site. If pipelines are required they will be located within defined road service corridors.

The sewerage treatment plant will be a package type unit providing the appropriate level of treatment. Treated effluent will be disposed of within the RSFs or recycled through the processing circuits. Sludge residues will be disposed of by a local (Alice Springs) contractor on regular basis as required.

Raw water demand for potable uses will be treated by a filtration and treatment system rated at approximately 250 m^3 per day.

3.10.7 Domestic waste

Domestic waste will include industrial waste, general waste, batteries and tyres. Waste will be managed in accordance with the waste hierarchy where practicable. An on site waste facility will be constructed and managed in accordance with the NT EPA guidelines for the siting, design and management of solid waste disposal sites. Listed waste will be transported for disposal at the licenced waste operator in Alice Springs.

3.11 Water management

3.11.1 Water balance

Arafura intends to design, operate and manage the Nolans site as a zero surface water discharge operation to limit the potential contamination of natural drainage features downstream of the operation.

The overall site raw water demand is projected to be 4,777 ML/y. This includes a demand for processing plant process water of 4,418 ML/y, potable water 91.5 ML/y, and water for dust suppression 267 ML/y (Table 3-14).

On-site water resources will be available from pit dewatering which, due to the limited spatial extent and porous and transmissive nature of the ore body, will be achieved through pumping from bores and/or from in pit sumps to on-site turkeys nest dam. Also available on-site is the recycling of tailings supernatant water that collects within the TSF ponds. Additional on-site water may be available from stormwater management ponds but this is likely to be less significant due to its low frequency of occurrence and limited volume.

A comparison of site water demand with available on-site water resources (Table 3-15) shows that the site will eventually have a water deficit as mine dewatering volumes decline. Additional water will be pumped from the borefield in the Southern Basins to compensate.

Table 3-14 Nolans site water demand

User	Demand (ML/y)
Mine / Concentrator	13.5
Crusher dust suppression	25
Beneficiation make-up	667
Processing plant raw water	2,990
Processing plant potable water	20

User	Demand (ML/y)
Impurity removal residue re-slurry water (RO Plant reject for re-slurry and RO Reject Plant surplus)	761
Mine and haul road dust suppression	242
Accommodation village potable water	58
Total	**4,777**

Table 3-15 Water balance of the mine for average rainfall year (sourced from Appendix I)

Component	Stage 1 (ML/yr)	Stage 2 (ML/yr)	Stage 3 (ML/yr)	Stage 4 (ML/yr)	Stage 5 (ML/yr)	Stage 6 (ML/yr)	Stage 7 (ML/yr)
Open pit rainfall inflow	32	101	139	191	262	335	385
Open pit Groundwater inflow	1088	1243	1243	1391	1451	1461	1461
Open pit Rainfall losses	-28	-91	-125	-172	-236	-301	-346
Open pit de-watering requirement [B]	-1091	-1253	-1257	-1410	-1477	-1495	-1500
Recycling of the TSF supernatant water[A]	2.7	6.1	3.3	9.4	25.7	30.0	12.4
Process water demand (excluding dust suppression)[C]	405	884	479	1399	3792	4418	1841
Dewater + recycle – process demand	689	376	782	20	-2289	-2893	-328
Water deficit (excluding dust suppression)	0	0	0	0	2289	2893	328

Notes: source: [A] pro-rated and based on % reclaim from 'Nolans Project Tailings Storage Facilities Engineering Cost Study, Lycopodium, February 2014' [B] Appendix E of Appendix I [C] Section 4.2

3.11.2 Water supply

Raw water to supply the processing plant and the concentrator will be pumped from an aquifer located in the borefield approximately 25 km to the south west of the processing site. Water will be supplied from multiple active bores at Reaphook Hills borefield area pumping variable rates in accordance with the operation's groundwater management plan to ensure the long-term sustainability of the borefield aquifer system. The actual number of borefields developed will depend on the results of future borefield groundwater investigations to be completed during the mine development phase. The combined maximum sustainable supply of the bores amounts to 6,783 ML/y.

The borefield pumps will be located within fenced compounds containing the head works, manifold, power and control equipment and power supply. A staged pumping system with an intermediate pond and transfer pumping facility has been selected to reduce pump size and pipeline pressure ratings. This system and the associated network of bores will be controlled remotely from the processing plant using telemetry. The transfer pipeline from the intermediate pumping station to the processing plant will run within the access track and overhead power line corridor.

It is anticipated that the raw water demand for potable uses can be supplied from the northern part of the borefield area via a dedicated small transfer pipeline to a treatment facility (size 0.25 Ml/day) at the processing plant. An alternative option of using the main raw water supply is also available. The raw water will be treated by a packaged filtration and treatment system. Once treated, the brine will be sent to evaporation ponds and the potable water will be stored in a potable water tank located within the processing plant. This tank has been sized for two days' storage to cater for unplanned outage events.

Potable water from the tank will be pumped to tanks located within the concentrator / mine services area and the accommodation village via HDPE piping. These transfer pipelines will be located within the road service corridors. All tanks will be fitted with chemical dosing and UV treatment facilities and have protected water reserves for connection to fire systems, safety showers, etc.

3.12 Transport and communications

The materials transport and logistics strategy will use, wherever possible, standardised equipment to optimise performance within the existing regulatory framework.

Additionally, the proximity of the Nolans site to both Alice Springs (135 km to the south east along the Stuart Highway) and Ti Tree (55 km to the north-northeast along the Stuart Highway) facilitates:

- A bus-in bus-out (BIBO) transport strategy for the movement of mine personnel to and from the accommodation village
- An opportunity to base significant maintenance and operations logistical infrastructure associated with the road transport operation in Alice Springs using existing infrastructure and local suppliers and
- The use of the Darwin to Adelaide rail line and rail infrastructure in Alice Springs, to support the total rail transport requirements of the project.

The rail corridor provides direct linkage to the Port of Darwin which is approximately 1,400 km to the north. Port Adelaide to the south offers an alternative back up port facility with very good infrastructure and a similar haul distance, thereby substantially enhancing the security of the supply chain.

Vehicles that are too wide to travel on normal roads will be serviced on site at the mining workshop.

3.12.1 Haulage roads

The mining method is based on a drill, blast, load, haul and dump to the ROM pad, stockpiles or WRDs involving:

- Up to 11 x Caterpillar 777F, 90 t class haul trucks and
- Up to 3 x Hitachi EX1200, 110 t class, diesel hydraulic excavators with 6 m^3 buckets.

All dual pit access ramps have been designed at 30 m width to allow safe two-way access for mine trucks up to 150 t class. One-way pit ramps have been designed with 16 m width with the exception of access to pit bottom where the single ramp width is 30 m.

A short haul road from the pit to the ROM pad will be constructed to allow dump trucks to pass. Interaction with light vehicles and other mine vehicles will be strictly controlled with standard industry protocols to ensure the safety of all personnel and equipment.

3.12.2 Materials transport

The under-utilised capacity on the south bound Darwin – Alice Springs – Adelaide train route will be used to transport quicklime, reagents and sulfur to the Nolans site from Darwin. Rare earth intermediate products from the processing site will also use the railway to Darwin via Alice Springs.

Outbound product will be trucked to Alice Springs in shipping containers after cleaning at the processing plant following unloading of reagents. The RE intermediate product within these containers will be contained in 1 tonne bulk bags. Outbound product will be transported from Alice Springs by rail to Darwin whilst inbound materials are transported by rail from the Port of Darwin.

No material will be transported in bulk with the exception of the carbonate from the planned Woodforde quarry. This may be transported in triple off-road side-tipping road trains.

Once operational the processing plant demand for sulfuric acid will be serviced by an on-site sulfur burning acid plant. Inbound sulfur will be procured on the international sulfur market and it is proposed that bulk shipments be containerised in Darwin for ease of transport by rail to Alice Springs and then road to the Nolans site.

The delivery of reagents and materials for the project will be managed from Alice Springs by an existing logistics operator. Transportation of these materials and reagents will be by standard road trains or B-double truck configurations with 2-3 trucks completing two trips per twelve-hour cycle from Alice Springs to the Nolans site. The quantities of reagent and materials are included in Chapter 17.

Historically the Port of Darwin has handled solid sulfur shipments and Arafura is working with the Port Authority and port operators to finalise the optimal location for a transfer facility.

All vehicles leaving the designated dirty zone at the Nolans site will be washed prior to leaving site. All 20 ft containers will be washed internally, unless dedicated to a specific material (e.g. quicklime). No ISO container will require internal washing.

A summary of the material movement between the mine site and transhipment facilities is provided in Figure 3-15 and Figure 3-16.

3.12.3 Communications

The Nolans site communications networks will comprise multiple systems designed for the required functionality, security and integrity. These systems include:

- Nolans site-wide control system network including telemetry links for remote control and monitoring
- Wide area network linking national network and corporate functions
- Local area network (business)
- Telephony and VOIP
- Radio system
- Mobile phone network and
- Village entertainment network.

The cable infrastructure for these systems will use defined access and infrastructure corridors. Other radio/microwave transmission and receiving structures will be mounted wherever possible on existing other multiuse structures.

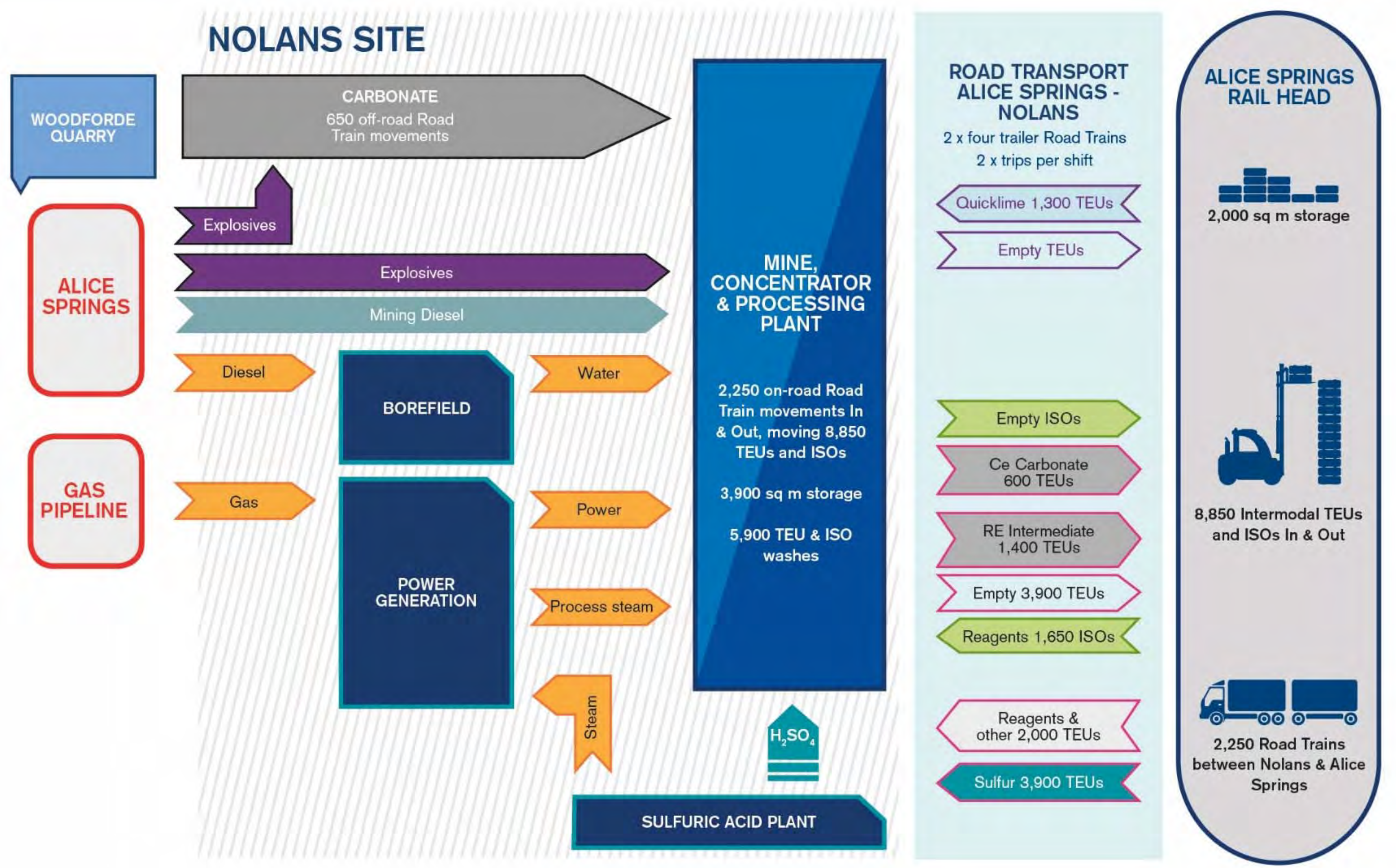

Figure 3-15 Nolans site - Alice Springs transportation (Source: Arafura 2014)

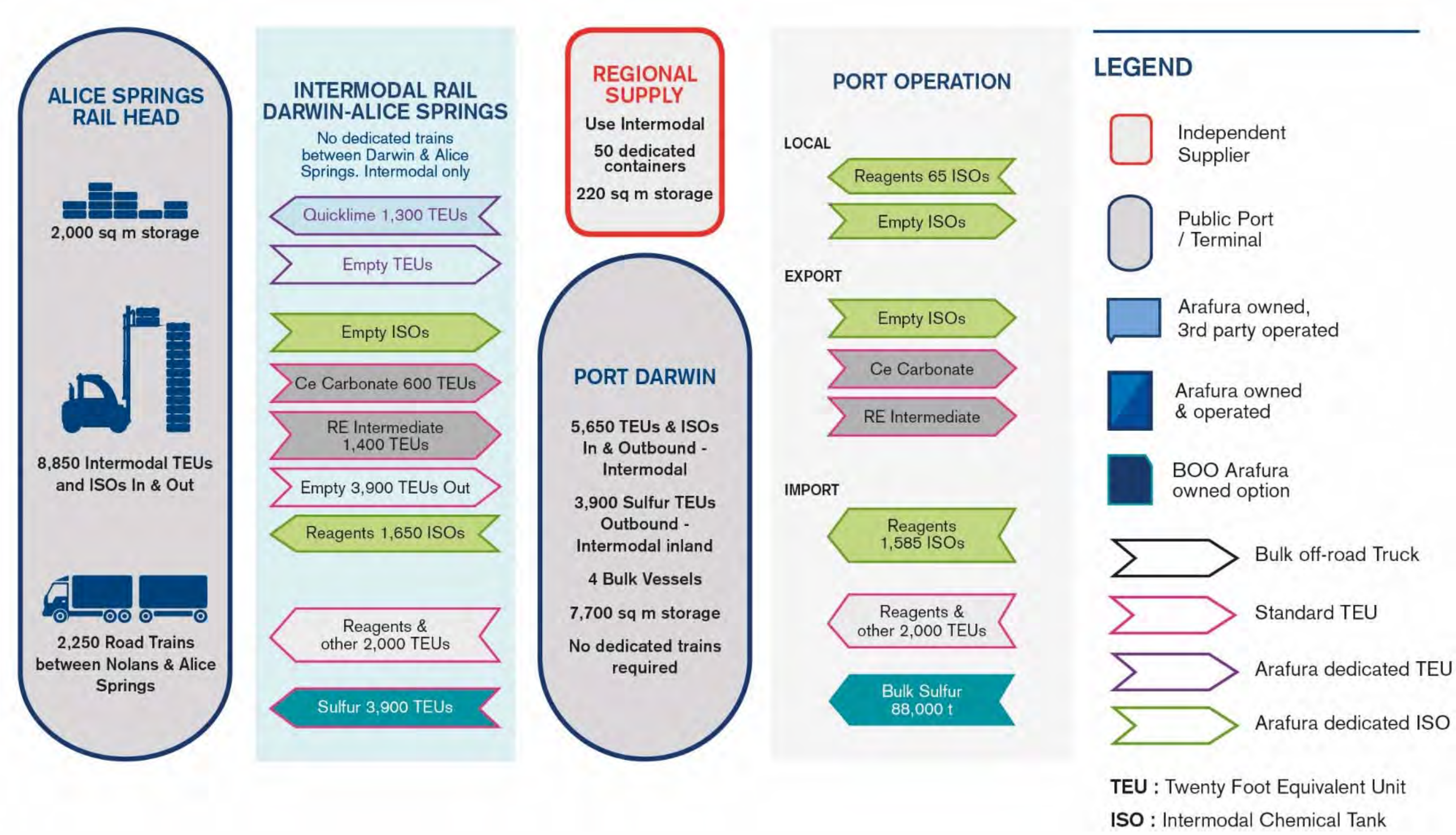

Figure 3-16 Alice Springs – Darwin transportation (Source: Arafura 2014)

3.13 Air

3.13.1 Inventory of air emissions

The inventory of air emissions for the project (detailed in Chapter 13) comprises dust and gaseous generating sources.

Dust generating sources

Dust generating sources are limited to the mine site and include:

- **The open pit and mining environment**

  As the ore body is generally within the aquifer (which will be dewatered ahead of mining), it is envisaged that the ore will have high moisture content and dust generation when mining will be lower than mining waste. Conventional mining methods will be employed using excavators, dump trucks and dozers with limited augmentation from blasting. Mining will progress through the seven stages, and peak years have been identified for each stage (corresponding to nominal year of mine operation) to identify material transfer to be used in developing the emission inventory across seven worst-case scenarios.

  Blasting is not the primary mining method, but will be used on a required basis. It is likely that ammonium nitrate fuel oil (ANFO) will be used in the waste rock because it is hard and relatively dry, while emulsion will be used in the ore as it is porous and a wetter material.

- **Haul road network within the mine site**

  Overburden and waste material will be deposited in purpose constructed WRDs via haul trucks. Dust suppression for haul roads and operating areas (in pit as well as WRDs and ROM pad) is required to limit dust inhalation by pit personnel (radiation requirements) and provide safe visual operating conditions.

- **Stockpiles and concentrator plant**

  Mining operations will deliver broken ore to a ROM pad (from which a front end loader will feed the crushing circuit) as well as to the LTS.

  Flotation tailings are transferred to a TSF. The tailings will be wet and so dust emission from these will be insignificant except if they dry out around their edges.

  Thorium and uranium will be present in the feed material to the concentrator and in material that is both stockpiled and/or disposed to WRDs. Radiation will be emitted and these are to be modelled as area sources from stockpile and waste sources.

  A (non-emitting) slurry transfer pipeline feeds concentrate across to the processing plant at a rate of 52 m^3 per hour.

- **Wind erosion from the mine site**

  A topsoil storage with a footprint of 95 ha and height of three metres is will be present. It will be used and refilled progressively as WRDs are built and closed. Waste soil that is removed from WRD footprints will be added into the stockpile for reuse.

- **Processing site**

  The processing site will require construction of RE extraction processing units, RSFs and evaporation ponds. The waste process residues will be wet and fine.

Gaseous generating sources

Gaseous generating sources will be based at the processing site and include:

- **Processing plant**

  The processing plant emissions will have purpose built scrubbers.

- **Sulfuric acid plant**

  Once operational the processing plant demand for sulfuric acid will be serviced by an on-site sulfur-burning acid plant. It is assumed that the sulfuric acid plant will have a standard arrangement for obtaining SO_2 emissions of 4 lb/ST (2 kg/MT) or 99.7% conversion. Given the sulfur feed rate (11.7 tonnes/hr) the emissions of sulfur dioxide can be calculated.

- **Power station**

  Power demand will be serviced by cogeneration from a sulfuric acid plant and gas-fired on-site generation supplied by a group of combined cycle gas turbine-based generators. The primary pollutants of concern from a gas-fired plant are nitrogen oxides and carbon monoxide. Emissions of particulate matter, sulfur dioxide and other substances have not been considered due to a low emissions value.

3.13.2 Emission controls and dust suppression

Dust emissions from haul trucks can be minimised using various control techniques (discussed in Chapter 13); however, emissions from dumping waste rock have no controls. Only unquantifiable operational controls can be applied to waste rock dumping. These operational controls include gentle dumping of overburden on the WRDs.

A summary of the controls applied for the air emissions modelling are provided in Chapter 13. A maximum 74 per cent reduction in emissions from mining activities was found to be achievable with the application of identified control measures

3.14 Workforce and accommodation

3.14.1 Workforce

The construction and operations workforces are expected to peak at 500 and 300 respectively, however until detailed engineering and construction schedules are finalised, these numbers may change. It is anticipated that the operational workforce will include approximately fifty specialist / skilled positions.

It is expected that the workforce will comprise approximately 70% fly-in fly-out (FIFO) ex Alice Springs, and 30% BIBO ex Alice Springs and other local communities. It is anticipated that the BIBO component of the workforce will comprise 1/3 local workers (i.e. from Alice Springs and surrounding communities), 1/3 NT workers and 1/3 interstate workers who will move to the region to live.

Workers may work a two weeks on, one week off roster and will be housed in a dedicated accommodation village at the Nolans site, with overflow accommodation needs likely to be met by the nearby Aileron Roadhouse during operations. An additional 200-room temporary accommodation camp will be leased over the project’s construction period and will be removed following commissioning of the processing plant.

Workers will be required to use a dedicated bus service to travel to and from the Nolans site to Alice Springs or their local community at the beginning and end of their roster. Contractors are expected to be able to use their own vehicles to get to and from the Nolans site. Roster changes will be timed to coincide with flights in and out of Alice Springs to minimise the amount of time FIFO workers have to wait in Alice Springs.

Environmental management positions

Professional environmental staff will be employed to manage and undertake environmental management duties on the site. The number of staff will be directly proportional to the workload requirements both during construction and operations.

3.14.2 Accommodation

The accommodation village will be laid out to make use of the natural grade for drainage and earthworks and will be subject to a detailed site survey and geotechnical investigation.

The accommodation buildings have been set back to the rear of the site and the central facility buildings and utilities have been located at the front where they will be easily accessible for delivery vehicles. A light vehicle parking area will be located in front of the facility, as will bus drop off and pick up areas.

The most practical construction system for the village will be offsite prefabricated transportable buildings. These buildings are mostly of a modular type construction with larger buildings being multi-module style.

The buildings will use a range of noise and thermal insulation techniques to provide comfort and maximise energy efficiency. The central facility buildings will include the following:

- Kitchen and dining building with the capacity to comfortably cater for up to 400 people at up to 100 percent occupancy. A wet mess will also be included as part of the site facilities.
- Village administration building, office and shop.
- Recreation building that provides for a range of functions including inductions during construction, meeting hall and general assembly building.

Accommodation buildings will generally be provided as single module structures with a number of accommodation units per building. Each unit will comprise a small bed sit room and an ensuite bathroom. A small number of larger size rooms will be provided and these rooms will have separate bed and sitting rooms with facilities to allow personnel to use the accommodation as office space. Two accommodation rooms for disabled persons have also been included in the building design. A gymnasium and swimming pool have been included for recreation.

Utilities services to be provided to the accommodation village include:

- Potable water - Treated water (filtered and chlorinated) will be pumped from the processing plant to the village where it will be stored in a single tank. The tank has been sized for two days' storage and will be divided into a higher level off take for potable supply and a secure (protected) lower level off take for fire systems. A constant pressure variable flow pump system will deliver potable water around the village using a buried pipe reticulation system. The water will be UV treated by lights in the line as part of the pump skid system. A temporary water supply will need to be established as an interim measure until the plant supply system is commissioned. Depending on the timing for establishment of bores, it may be necessary to truck potable water to site during the initial months.

- Fire systems will include detection systems and active fire suppression systems. Detection systems will include hard wired smoke detectors to all buildings and break glass audible alarms. Suppression systems will include extinguishers fixed outside all buildings, full hose reel coverage of the village and several hydrants located strategically around the core facilities. The hydrants will be supplied from a dedicated electric / diesel fire pump system. A fire break will be maintained around the outer perimeter of the village to minimise the risk from grass/wild fires. Hydrant / hose reel coverage of the perimeter around the village will also be provided. Fire support will be available from a fire unit located at the processing plant.
- Sewage will be collected from around the village using a conventional gravity reticulation system. This will drain to a single pump station within the village compound. From the pump station, sewage will be pumped to a treatment plant located near the processing plant. The treatment plant will be a package type unit providing a level of treatment in compliance with environmental approval conditions.
- Power will be generated at the processing site and transmitted to the village by overhead high voltage (11 kV) conductors. At the village there will be a kiosk substation from where power will be reticulated below ground at low voltage (415 V). Sub mains will lead from the substation to local distribution panels, which will in turn feed the individual building modules. While the process plant is under construction, power will be generated at the village using temporary diesel gensets. One or two of these gensets will be retained in the longer term to provide temporary backup for essential village services in the event of a power outage.
- Communications in the village will comprise mobile telephone services, two-way radio, data / internet services, and television / entertainment services. The provision of head services has been included in the mine and concentrator estimate scope. Reticulation of communications around the village will be achieved using a fibre backbone system installed in common trenching with other utilities. A separate communications building will be established.

Application of the *Department of Health Fact Sheet No. 700 Requirements for Mining and Construction Projects* will be considered during detailed design and operation of the project. The serving of alcohol on site will be in accordance with NT licencing requirements.